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Municipal Solid Waste Disposal in Estuaries and Coastal Marshlands

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Glastonbury, CT

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MUNICIPAL SOLID WASTE DISPOSAL IN ESTUARIES AND COASTAL MARSHLANDS

by

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Contract No. 68-03-2517

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16. ABSTRACT

The study was accomplished through: questionnaire survey on disposal practices of the coastal states and Puerto Rico that identified the extent of monitoring data available; site visits to state agencies possessing significant monitoring data; and a survey/analysis of State and Federal regulations. In addition an extensive search of both the formal scientific literature and the "gray" technical report literature was conducted. Recommendations for improvements in regulations, for the mitigation of adverse environmental effects of MSW disposal in the coastal zone and an extensive bibliography are also provided.

This study reached the following conclusions:

- MSW disposal sites should be located to prevent leachate migration; operated to minimize leachate production; and monitored and regulated to control the detrimental effects to the environment.
- The impact of municipal solid waste disposal on coastal ecosystems has not been analyzed in depth by either the scientific or the regulatory community.
- The only well-docuemtned impact is habitat depletion. There is a high probability that this is also the most serious impact resulting from MSW disposal.
- There are circumstances in which coastal MSW disposal can be used for beneficial purposes, e.g., to provide a substrate for habitat creation.

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, to preserve and treat public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report is a survey of the existing situation with regards to municipal solid waste disposal in the coastal zone. Both the scientific literature and the regulatory community were surveyed to determine the state-of-knowledge of the impact of such disposal on the environment, past and present disposal techniques, and the attitudes of the regulatory community.

Francis T. Mayo, Director
Municipal Environmental Research
Laboratory

ABSTRACT

This report summarizes past and present instances of municipal solid waste (MSW) disposal in estuaries and coastal marshlands and the environmental impacts from such waste disposal were investigated. The study was accomplished through: an initial questionnaire survey on disposal practices to the coastal states and Puerto Rico that identified the extent of monitoring data available; a number of site visits to state agencies possessing significant monitoring data; and a survey/analysis of State and Federal regulations pertaining to MSW disposal and permitting requirements. In addition an extensive search of both the formal scientific literature and the "gray" technical report literature was conducted. Recommendations for improvements in regulations and for the mitigation of adverse environmental effects of MSW disposal in the coastal zone are also provided.

This study reached the following conclusions:

- MSW disposal sites should be located with consideration of geologic and hydrologic site characteristics to prevent leachate migration; operated so as to minimize leachate production; and monitored and regulated to control the detrimental effects to the environment.
- The impact of municipal solid waste disposal on coastal ecosystems has not been analyzed in depth by either the scientific or the regulatory community.
- The only well-documented impact is habitat depletion. There is a high probability that this is also the most serious impact resulting from MSW disposal.
- There are circumstances in which coastal MSW disposal can be used for beneficial purposes, e.g., to provide a substrate for habitat creation.

This report wassubmitted in fulfillment of Contract No. 68-03-2517 by Management of Resources and the Environment, Glastonbury, Connecticut, under the sponsorship of the U.S. Environmental Protection Agency. Work was completed as of June 1980, with minor revisions made in May 1980.

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CONVERSION FACTORS

Length
1 inch = 2.540 cm
1 foot = 30.48 cm
1 mile = 1.609 km
1 cm = 0.3937 inches
1 m = 39.37 inches
1 km = 0.6214 miles

Area
1 sq. meter = 10.76 ft^2
1 hectare = 2.47 acres

Volume
1 cubic foot = $2.832 \times 10^{-2} m^3$
1 cubic meter = 35.31 ft^3

Weight
1 metric ton = 1.1 tons
.982 tons = 1 metric ton

Pressure
1 $lb./in^2 = 6.895 \times 10^4$ $dyne/cm^2$
1 $dyne/cm^2 = 1.450 \times 10^{-5}$ lb/in^2
1 $dyne/cm^2 = 2.089 \times 10^{-3}$ lb/ft^2

Note:
Measurements given in the Federal and State Regulatory Section of this report (Section 4) are in English Units as they appeared in the regulations.

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SECTION 1

INTRODUCTION

This project was undertaken to document the present environmental effects of municipal solid waste (MSW) disposal in estuarine and coastal marshlands. The study process involved (1) a complete investigation of disposal operations in the coastal states, encompassing an initial questionnaire survey to the states; (2) a thorough evaluation of the applicable regulations and permitting procedures of disposal operations; (3) an intensive review of the literature pertaining to the effects of this type of waste disposal; and (4) our recommendations for future regulatory directions and mitigation of adverse environmental effects of municipal solid waste disposal in the coastal zone.

Section 2, Conclusions, summarizes the study results briefly, and Section 3, Recommendations, suggests needed improvements in disposal practices and legislation.

Section 4 of this report, Methods, describes the various steps taken to gather background information necessary to complete the investigation. How the literature search was accomplished, the design and results of the initial questionnaire survey, the objectives of the selected site visits, and an overview of the regulatory analysis are all presented.

Section 5, Questionnaire Response gives the rate of response of both the initial questionnaire and the follow-up letters to nonrespondents.

Section 6, Regulatory Analysis, provides a breakdown of both State and Federal regulations that pertain to solid waste disposal and the coastal zone. Comparisons are made of the varying degrees of regulatory and enforcement control.

Section 7, Documentation of the Environmental Effects of Past and Continuing Operations, presents the results of the literature survey and a site by site summary of results and analysis of data acquisition which was available from the States selected for site visits.

SECTION 2

CONCLUSIONS

This study on the disposal of solid waste in a saline environment affirms the importance of following accepted and proven practices for sanitary landfill design and operation. Though they seem simplistic, the basic criteria for good landfill operation are still selection of a site that has the necessary geologic/hydrologic characteristics to prevent migration of leachate, operating procedures that minimize leachate production, and good monitoring systems that assure continued operation of the landfill in an environmentally positive manner.

Significant effort was put into the literature search, which revealed that much research needs to be done on the effects of landfills on saline environments. Little if any landfill information was found in the published literature, yet a significant amount of information was found in individual State files. States with significant information were identified through the use of mailed questionnaires. A surprisingly large quantity of hard monitoring data and observational information were found to exist on the State level.

The individual site visits were crucial to the study and included the States of New York, New Jersey, Louisiana, Washington, California, Connecticut, South Carolina, and Maryland. The study team members uncovered meaningful data, despite some significant differences among State regulatory powers, monitoring requirements, enforcement procedures and penalties, and attitudes toward the regulation of landfills. Clearly, those States with a high environmental sensitivity approach the problem of solid waste disposal and regulation differently than coastal States, which may be under pressure to develop scarce land.

The study revealed that documentation of the environmental effect of landfills is currently being undertaken in much more detail by some State regulatory agencies than in previous years. There is a definite gap, however, in background/baseline information, especially for those landfills that have been operating for more than 20 years. As existing landfills become designated for upgrading and eventual closing, the States begin to conduct more intensive monitoring. In many instances, it is difficult to determine what existed at the site before the development and operation of the landfill. As is the case with upland sites, the effect of continued operation of the landfill within a marine environment depends on the individual site characteristics and the vigorousness with which the operation is regulated.

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SECTION 3

RECOMMENDATIONS

Recommendations for improved disposal practices and legislation and enforcement are listed as follows and are discussed briefly later in this section.

DISPOSAL PRACTICES

1. Coastal areas should be protected from unwise development resulting in destruction of wildlife habitats.

2. Municipal solid waste should be disposed of in an environmentally safe manner in saline environments.

    a. Accepted landfilling practices should be employed to assure safe operation of landfills in saline environments.

    b. Those landfills that contribute significant leachate to the environment must be closed despite the significant pressure that is placed on them for continued operation.

3. A regional approach should be taken to solid waste management to:

    a. Avoid duplication of efforts;

    b. Make expert advice and assistance available to smaller communities;

    c. Isolate decisions concerning the planning and siting of facilities from local political concerns; and

    d. Minimize discrepancies in disposal sites among neighboring municipalities.

LEGISLATION AND ENFORCEMENT

1. Legislation must be enacted to prevent the further destruction of wildlife habitats. Emphasis should be shifted from concern over future degradation to recognizing and rectifying damage that has already been done in saline environments.

2. Legislation regarding solid waste management should be upgraded and coordinated on the Federal, State, and local levels.

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    a. Communications must be improved between State and local agencies regarding permitting and operating requirements and economically feasible methods of solid waste disposal.

    b. The degree of regulatory control over MSW disposal should be equalized on the State level.

3. Effective strategies must be developed for implementation and enforcement of environmental safeguards.

DISCUSSION OF RECOMMENDATIONS

Disposal Practices

Protection of Wildlife Habitats--

In reviewing the available scientific literature, it is apparent that the only documented effect of solid waste disposal in a saline environment is that of wildlife habitat destruction and the resulting decline in productivity. This is a generic problem common to any dredge/fill operation in estuarine coastal habitats. No evidence exists that points to the destruction of adjacent wetlands as a result of direct leachate contamination. In fact, in one case, specifically in the Hackensack Meadowlands area, a productive freshwater wetland and a saltwater marsh exist adjacent to an operating landfill and receive leachate directly with no visible impact. However, the effect of any chemical, toxic or otherwise, will not be obvious if the dilution is sufficient to mask its effects. Since saline habitats are flushed by the tide, adverse impacts may be less apparent. The significant problem lies in the subtle, sub-lethal consequences of continued pollution that may defy current monitoring capabilities. Leachate pollution may be profoundly altering some aspect of the ecosystem rather than directly affecting individuals. Basic research into community structure needs to be undertaken to develop techniques to determine the subtle long-term effects of leachate on the environment. The problem is further complicated in considering the variation between "new" and "old" leachate. Leachate produced as waste begins to decompose, has a high BOD, and is readily treated by present-day biological methods. As waste begins to stabilize, the leachate produced has a high COD and requires expensive physical/chemical treatment.

Technologically, it is possible to dispose of municipal solid waste in an environmentally safe manner. The method employed is sanitary landfilling, which primarily involves minimizing the infiltration of water to prevent leachate production and the isolation of waste from ground and surface waters through natural and artificial barriers, combined with collection and recirculation or treatment of any leachate produced.

Since the technology exists for creating an environmentally safe sanitary landfill, it is not necessary to prevent completely the disposal of solid waste in coastal areas, although care must be taken to assure proper siting. However, the problem of wildlife habitat loss is still of major significance as human populations make increasing demands on limited coastal land resources.

Use of Safe Disposal Methods--

The continued operation of landfills in saline environments should naturally continue under sanitary landfill conditions. The obvious design and operational characteristics of the sanitary landfill must be adhered to in order to make any landfill, whether in a saline or upland environment, acceptable to the affected land. The minimization of leachate production is of crucial importance. This problem occurs more often in the northeast and other high-rainfall areas than in more arid sections. But even in extremely wet areas, leachate production can be minimized. Methods for such control include use of tight daily cover material with a low permeability and the design of operational grading situations that allow for rapid runoff from the surface. In those landfills that exist and operate within the saline environment, the expansion or upgrading of the landfill can prove environmentally positive for the long run. Extraordinary grading plans can provide significant contributions to mitigating the intrusion of added moisture to the landfill mass.

The second most important item is the isolation of the landfill material from receiving waters. This isolation can be accomplished through a series of impermeable barriers, dikes and impoundment systems, and the incorporation of a drainage system that diverts any leachate produced from entering receiving waters. Evaluation of receiving waters and identification of sensitive ecosystems can provide significant information as to whether a landfill is indeed negatively affecting the natural environment. The rate of mixing of leachate produced, the transmission of the diluted material to adjacent ecosystems, and the capability of the system to recover from pollution impact determines whether the landfill is operating in an environmentally acceptable manner. The greatest pollution problem is with those landfills that were constructed in an environment where leachate production and transmittance will continue unless extraordinary efforts are made. The closing of landfills where leachate continues to enter into the groundwater and surface water regimes must occur. The technology for landfill closures is well documented and known throughout the country. Those landfills that can be stabilized and effectively neutralized can often be reclaimed through an aggressive revegetation and re-establishment program. If destruction of wildlife habitat has occurred, efforts should be made to provide for some habitat re-establishment. Although it is almost impossible to re-establish the habitat to the prelandfill situation, a reasonable substitution of ecosystem vegetation can be undertaken. Such an objective should be a high priority to landfill regulators. The precedent for re-establishing wildlife habitats has been firmly established under the RCRA, and the ability to achieve this at all sites has been well documented.

In low-rainfall regions of the country, techniques for recirculating leachate have important benefits. The leachate can be gathered through a series of collection channels and pits, pumped to the top of the landfill mass, and allowed to percolate through. By minimizing the continued entrance of rain water, and by spraying leachate onto the landfill mass, the pollutants and solids can be effectively concentrated in the uppermost layers of the mass. An effective closure can be incorporated into the total system.

Clearly, the technology exists for insuring environmental integrity of sanitary landfills, whether it be in a saline or upland site. The attached bibliography lists significant sources of information on technology for guaranteeing environmental protection. The largest problem at present is the closure of those landfills that have significant pressures placed upon them for continued operation despite their significant contribution of leachate to the environment.

Regional Approach to Solid Waste Management--

A regional approach to solid waste management is required to assure good communication among the various levels of government, to avoid duplication of effort at local levels, and to make available design, management, and technical expertise to smaller communities. Also, with the inclusion of many towns in one solid waste disposal region, it may be possible to isolate decisions concerning planning and siting of facilities from local political concerns.

The support of regional solid waste agencies also minimizes the possibility that disposal sites could vary significantly between neighboring municipalities. The continued operation of environmentally unacceptable disposal sites often depends on lack of economically attractive alternatives. Regionalization is a proven solution to such problems. Financial frameworks must be established that reimburse those localities that are providing for environmentally satisfactory disposal sites designed to accomodate waste streams from other geopolitical units.

Legislation

Preventing Destruction of Wildlife Habitats--

The most serious environmental impact of coastal zone solid waste disposal was found to be elimination of productive estuarine habitat and modification of coastal currents and sedimentation patterns. Even safe disposal methods such as liners, daily cover, and leachate treatment cannot prevent this destruction from occurring. Legislation must therefore be enacted to prevent further development in sensitive areas.

The protection of sensitive saline areas has been restricted in the past to preventing future degradation of the environment. We recommend that increased recognition be given to what these ecosystems have experienced to date as a result of solid waste deposition. Federal solid waste agencies can best provide technical and financial support to assist those States that have operating landfills within saline environments. Their eventual closing, continued use, or expansion (outside of sensitive regions) requires technical support and funding to assure environmental protection.

Upgrading and Coordinating Legislation and Control--

The various levels of government--Federal, State, and local--can work at cross purposes with one another without proper legislative and regulatory coordination.

Levels of Control--Our analysis of the levels of control exerted by the coastal states over municipal solid waste disposal revealed wide inconsistencies, particularly with regard to permitting requirements for location, design and operation criteria, and performance standards. In some States, control was very complete, but others exerted very little. With the implementation of the RCRA, however, a fairly uniform set of regulatory requirements will be imposed. Open dumps will be eliminated or upgraded to true sanitary landfills. It will be important, however, to prevent closure of relatively nonpolluting open dumps in cases where creation of properly engineered santiary landfills would cause wholesale destruction of wildlife habitat.

Communications--One problem inherent to coordinating the management of solid waste disposal involves the workings of State and local governments. Since the State often is the regulatory agency responding to technical and environmental concerns, and local governments are concerned with the actual mechanics of waste disposal from both an environmental and economic viewpoint, conflicts invariably arise. There must be effective communication between these two levels of government in terms of permitting and operating requirements and economically feasible methods of disposal. Such communication requires the establishment of regional solid waste management plans, as discussed earlier in this section.

Developing Strategies for Implementation and Enforcement--

Environmental safeguards are only as effective as the strategies for implementation and enforcement that accompany them. Adequate enforcement mechanisms, an effective enforcement agency, and strict penalties for violations are essential. Our review of the coastal States regarding this aspect of solid waste control showed broad and unacceptable variations.

Continuous Monitoring--Adequate enforcement measures must include a continuous, efficient monitoring program and some standardization of requirements. With research into the effects of leachate on ecosystems, it may eventually be possible to quantify dangerous levels of particular chemicals and establish monitoring procedures. At present, State monitoring requirements vary tremendously, and there is often no apparent beneficial end use for these data. This situation should be rectified.

Continued Responsibility for Operators--One particularly effective enforcement tool to assure protection of the environment involves the continuation of responsibility by the landfill operator following site closure. Because improperly disposed waste can cause severe groundwater pollution problems, and because there is increased reliance in many areas on groundwater as a water source, it is necessary to protect this valuable resource. Several States (California, Delaware, Florida, Georgia, New

Jersey, Washington) have incorporated a required performance bond or a continuous monitoring program for a specified period of time to insure that the landfill site is causing no environmental degradation. The RCRA recognizes the importance of such continuous monitoring efforts, but it must also be recognized that the most reliable and cost-effective method to eliminate solid waste pollution is strict operational and design standards to prevent leachate generation or to collect and treat it.

Use of Upland Criteria--The regulatory determination of what constitutes an acceptable operation usually varies, depending on the expertise of the reviewer and the background information available for his/her use. Criteria based on upland sites have been used to regulate many saline sites. In most areas, landfill classification depends on its waste stream and is independent of the site characteristics. We recommend that guidance be afforded to regulatory agencies on the characterization of the landfill sites. As discussed later in the report, saline ecosystems subjected to deposition of waste can experience impacts that are different from upland sites. The proximity of sensitive receptors so often present in saline ecosystems necessitates expanded monitoring systems not found in most typical sanitary landfills.

Viewing the Coastal System as a Whole--The coastal system should be considered as a total system, as is the case in California, and not in isolation. The continued operation and eventual closing of some of the landfills within the San Francisco Bay region proves that tight regulatory mechanisms can assure that landfills are operated in an environmentally positive way. Other States could benefit immeasurably by the adoption of the California system, which requires both a philosophical embracing of the regulatory mechanisms as well as the financial support for staffing and implementation. Technical support from professionals within the field of solid waste management can assure that landfills operate in an acceptable manner. Without the financial support for strong regulation and enforcement, however, the technical support is without value. Monitoring, enforcement, and recourse mechanisms are an integral part of the successful operation of landfills.

Realistic Penalties--The implementation of realistic penalties for nonconformance is necessary. In some cases, fines as low as $5.00 are the maximum penalty and are quite ineffective. Cease and desist orders without adequate enforcement powers are similarly ineffective. The solid waste management agency should have the discretion to utilize administrative, civil, and/or criminal remedies in a mix that is appropriate to the particular situation. Imposition of sanctions must, however, be tempered by offering solutions. Closure of a poorly sited landfill may only result in creation of another problem elsewhere.

Infusion of Federal Funds and Expertise--One of the primary factors preventing the States from effectively administering their solid waste management programs is a lack of manpower and funds. Without adequate review and inspection personnel, the most stringent regulatory program will be reduced to a procedural exercise without yielding substantive benefits. A direct infusion of Federal money and/or expertise at the level of primary waste management will be necessary to implement the RCRA requirements effectively and achieve the objectives of the Act.

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SECTION 4

METHODS

LITERATURE SEARCH

A number of computerized abstract data bases were initially used to gather the available published literature pertaining to municipal solid waste disposal in saline environments. This method was considered the most cost-effective means of extracting relevant information on the history, environmental impacts, and government view of this type of waste disposal. From the initial abstracts obtained, the cross-disciplinary, gray or fugitive literature was extracted, again using computerized access systems. Furthermore, because of the inevitable time lag between the date of publication of scientific articles and the date of their entry to computerized data bases, cross-indexing was undertaken by using the Scientific Citation Index of the Smithsonian Scientific Information Exchange, and by monitoring Current Contents, a journal containing copies of the tables of contents of various other journals.

The data bases accessed include the following:

Water Resources Scientific Information Center (WRSIC)

Solid Waste Information Retrieval System (SWIRS)

BIOSIS (Biological Abstracts)

Engineering Index (Endex)

Oceanic Abstracts

National Technical Information Service (NTIS)

Datrix

Office of Solid Waste Management Planning (OSWMP)

Pollution Abstracts

Enviroline

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Smithsonian Scientific Information
Exchange (SSIE)

Ph.D. Dissertations

Manual literature searches for relevant study information also were conducted in the U.S. Environmental Protection Agency (EPA) library, the Yale University Library of Forestry and Environmental Sciences, and the technical library of Management of Resources and the Environment (MRE).

Three courses of action were pursued to obtain the unpublished literature and State and municipal policies and attitudes toward disposal in the coastal zone. One was to send questionnaires to the government agencies responsible for municipal solid waste disposal in coastal and saline environments in all of the coastal States. The second course of action was to search the Smithsonian Scientific Information Exchange data base of ongoing and recently completed basic and applied research projects sponsored by more than 1,300 Federal, State, and local agencies, private foundations, and universities. And the third approach was to visit landfill sites to obtain monitoring data.

More than 3,000 literature citations were generated through the various search efforts of this study. A breakdown of the 221 citations selected for acquisition is given in Table 1 according to the data base from which they were obtained.

TABLE 1. DOCUMENTS RECOVERED THROUGH THE LITERATURE SEARCH, BY DATA BASE

Data base	Number of Useful Citations
WRSIC	55
SWIRS	23
BIOSIS	9
Endex	2
Oceanic Abstracts	7
NTIS	23
Pollution Abstracts	19
Datrix	1
EIS	1
Enviroline	9
OSWMP	4
SSIE	43
Other manual searches	25
Total	221

QUESTIONNAIRE SURVEY

Questionnaires were mailed to the government agencies responsible for coastal and estuarine MSW disposal in 23 coastal States and Puerto Rico. These 186 questionnaires were considered to be the best method for eliciting specific data on case histories, environmental impacts, and government attitudes toward this type of solid waste disposal.

The questionnaire contained both closed and open-ended questions. The closed items were designed to obtain factual responses on specific issues. For example: Have coastal saline environments been used as a repository for municipal solid waste in your State/city? Where are these located? How long was the site used? What type of waste was deposited? What type of operation was involved? The open-ended questions were designed to determine agency attitudes toward the costs, benefits, and public response to such waste disposal operations. The entire questionnaire is presented in Figure 1.

To collect the greatest quantity of useful data in the shortest time period, every attempt was made to determine which agencies within the States held primary responsibility for disposal in the marine environment. The water pollution and solid waste management statutes for each State were reviewed, and the agencies that were indicated as having the major responsibility were cross-checked with a file of U.S., State, and local environmental officials to develop an accurate, up-to-date list of agency names and addresses. Tables 2 and 3 describe the response to both the initial and supplemental mailings of the questionnaire.

SITE VISITS

The primary object of visits to the administrative and/or regulatory agencies with jurisdiction over solid waste disposal in estuarine and saline environments was to obtain detailed landfill site information that would be useful in evaluating the past, existing, or potential adverse environmental and economic effects of such landfills. Site visits were necessary to select data pertinent to our study and to interview those most knowledgeable about solid waste disposal. With the information derived from the individual site visits as well as the questionnaire surveys, it was possible to draw some conclusions regarding the environmental acceptability of various types of disposal and to recommend ways to mitigate the adverse impacts from past and continuing solid waste disposal operations.

The specific information sought at the various State offices included the geographical/geological location of the landfills, hydrological information, operational methods and capacities, and any monitoring data on the effects of the operations on the surrounding land, air, and ground and surface waters. It was hoped that before and after site information would be available. For each landfill site, the appropriate resources (if available) were examined for the following characteristics:

TABLE 2. RATE OF RESPONSE TO QUESTIONNAIRE MAILED AUGUST 4, 1978

State	Number of agencies contacted	Number of Responses			
		As of August 31	As of September 30	As of November 6*	Total
Alabama	7	2(1)†	0	0	2(1)
Alaska	6	1	0	0	1
California	19	10(2)	1	1	12(2)
Connecticut	12	3(3)	0	0	3(3)
Delaware	6	1(1)	2	0	3(1)
Florida	11	3(3)	1	0	4(3)
Georgia	7	1(1)	0	0	1(1)
Hawaii	8	1(1)	1	3	5(1)
Louisiana	5	2#	0	1	3#
Maine	10	5(4)	0	0	5(4)
Maryland	8	6(2)	0	1	7(2)
Massachusetts	5	1	0	0	1
Mississippi	3	3(1)	0	1	4(1)
New Hampshire	6	1(1)	0	0	1(1)
New Jersey	7	1(1)	1(1)	0	2(2)
New York	8	5(4)	0	0	5(4)
North Carolina	8	0	0	0	0
Oregon	9	2(1)	0	0	2(1)
Puerto Rico	7	2#	1	0	3#
Rhode Island	6	0	0	0	0
South Carolina	7	3(1)	1(1)	1	5(2)
Texas	8	1(1)	0	1	2(1)
Virginia	6	0	0	0	0
Washington	9	0	1	1(1)	2(1)
Total	188	54+(28)§	9(2)	10(1)	73(31)§

† Figures in parentheses indicate questionnaires that either did not supply meaningful information, were forwarded to a more appropriate agency, or had already been answered by the appropriate agency.

* Date of mailing of followup questionnaire.

Includes one return-to-sender.

§ Includes two return-to-senders.

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TABLE 3. RATE OF RESPONSE TO QUESTIONNAIRE FOLLOWUP MAILED NOV. 6, 1978

State	Number of letters sent	Number of Responses As of November 30	 As of December 31	 As of January 31	 Total
Alabama	6	3(2)*	1(1)	0	4(3)
Alaska	5	0	0	0	0
California	11	4(2)	1(1)	0	5(3)
Connecticut	12	2(2)	1(1)	0	3(3)
Delaware	4	3(3)	0	0	3(3)
Florida	10	3(3)	2(2)	0	5(5)
Georgia	7	2(2)	1	0	3(2)
Hawaii	6	1(1)	2(1)	0	3(2)
Louisiana	2	0	0	0	0
Maine	8	3(2)	0	0	3(2)
Maryland	4	1(1)	1(1)	0	2(2)
Massachusetts	4	1(1)	0	1	2(1)
Mississippi	1	2(2)	0	0	2(2)
New Hampshire	5	0	1(1)	0	1(1)
New Jersey	5	0	1(1)	0	1(1)
New York	6	0	4(2)	1	5(2)
North Carolina	8	2(2)	0	0	2(2)
Oregon	8	1(1)	0	0	1(1)
Puerto Rico	4	0	3(2)	0	3(2)
Rhode Island	6	1(1)	0	0	1(1)
South Carolina	5	3(2)	1	0	4(2)
Texas	4	0	0	0	0
Virginia	6	0	1(1)	0	1(1)
Washington	8	1(1)	1(1)	0	2(2)
Total	145	33(28)	21(15)	2	56(43)

* Figures in parentheses indicate questionnaires that either did not supply meaningful information, were forwarded to a more appropriate agency, or had already been answered by the appropriate agency.

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- .Location -- topographical and site plan maps
- .Hydrology -- surface and groundwater levels and flow directions, presence of saltwater wedges
- .Geology -- surficial deposits, depth to bedrock, and porosity of soils
- .Landfill operation -- areal extent, duration, amount and type of deposited material, and volume and amount of compaction
- .Landfill effects -- leachate generation, surface and groundwater quality, bioassays, and gas generation

See the list of site visit information objectives in Appendix B.

The choice of States to be visited for a more in-depth analysis of landfill disposal operations was relatively easy to make. Many of the 23 coastal States, along with Puerto Rico, indicated having a dearth of, or at best, a minimal quantity of useful monitoring data, and these were consequently eliminated from consideration for possible site visits. Conversely, one State, California, indicated that a wealth of monitoring data existed, but because of budgetary constraints imposed by the passage of recent legislation, there was no available manpower to extract the relevant information for our study purposes. California, therefore, was chosen for a site visit, along with six other States that indicated that relevant and useful background and monitoring data were available: Connecticut, Louisiana, Maryland, New York, New Jersey and South Carolina.

REGULATORY ANALYSIS

State and Federal laws were studied, compared, and analyzed as they pertained to the disposal of MSW in a saline environment. Types of laws that were investigated included those regulating solid waste disposal, solid waste management, resource recovery, sanitary landfill management, water pollution, coastal activity, coastal wetlands, wetlands, land use and site location. Each law was examined for its applicability, purpose, and prohibitions, control, including enforcement and penalties, permit requirements, and specific requirements pertaining to disposal of waste. Much of this information is organized in tabular form in Section 6 and includes applicable laws, permit requirements for solid waste disposal sites and facilities, enforcement and penalties for violation, and specific waste disposal requirements. Further analyses were developed of the control exerted by coastal States over MSW disposal.

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Name of Respondent:______________________________________
Organization:____
Address:____________________________Telephone:____________

A. Have there been past, or are there ongoing instances of municipal solid waste disposal in coastal saline marsh areas of your State?___ ___

B. Has monitoring or testing of environmental conditions of these operations ever been conducted? ____ ____

(If yes, please complete the following for each site for which monitoring or testing of environmental conditions has been conducted and for which data exist. Use additional sheets for multiple areas).

1. Identification of disposal site(s) (name/location)____________
2. Years of operation 19 through 19
3. Type of waste deposited__________________________________
4. Type of operation and duration in years
   crush & cover_______ burning______ uncovered operation_____
5. Describe environmental quality testing undertaken. Type of information gathered, when, agency performing testing._________
6. Would you please forward copies of the program described in #5 above and the results obtained?__________
7. Responsible regulatory agency, group or individual having additional information: (including phone no. & address).___________

NOTE: The following questions may require the use of additional sheets for answering. Please staple them to this questionnaire.

C. What will be the effect of Federal regulations severely restricting solid waste disposal in estuarine and coastal marshlands and floodplains on your solid waste management program? Please circle your response.

a. No effect. This is already prohibited by State and/or local laws.
b. Some effect, especially in the following situations:___________
c. Significant effect, especially in the following situations:____

D. If your agency has previously considered disposal in the coastal zone a viable alternative to deal with the solid waste problem, why has it done so?

____

E. What problems, both technical and with the public, have you encountered concerning solid waste disposal sites in estuarine and coastal marshlands?

____

F. What benefits do you see, both technical and from the public, from restricting solid waste disposal in estuarine and coastal marshlands?______

Figure 1. Simplified version of questionnaire.

SECTION 5

REGULATORY ANALYSIS

FEDERAL CONTROL

Until recently the Federal government took no direct regulatory control over solid waste management. Actual or potential indirect control existed through several statutes, such as the Rivers and Harbors Act of 1899, the Federal Water Pollution Control Act Amendments of 1972 (hereafter called the Clean Water Act), and executive orders such as Executive Orders 11988 and 11990 (both dated May 24, 1977) on Floodplain Management and Protection of Wetlands. This situation changed dramatically with the passage of the RCRA (PL 94-580) on October 21, 1976. This legislation replaced the Solid Waste Disposal Act and provided for direct, centralized regulation of all solid waste disposal in the United States under a joint Federal-State regulatory scheme administered by EPA in a manner similar to the Clean Air and Clean Water Acts.

To provide a background against which the breadth and potential influence of the RCRA can be assessed, the potential control mechanisms existing outside the Act will be described briefly, followed by a more comprehensive examination of the RCRA itself, and of proposed EPA regulations and technical guidelines. Note that because of the fluid nature of the regulatory process and the need to prepare this report in a timely fashion, the description of the RCRA regulations may not be completely up to date. At the time this document was submitted for publication, both the Criteria for Classification of Solid Waste Disposal Facilities and the Guidelines were in draft form, with publication of the final documents imminent.

Rivers And Harbors Act Of 1899

Before enactment of the RCRA, Section 13 of the Rivers and Harbors Act (sometimes known as the Refuse Act) was potentially the strongest vehicle for preventing unreasonable destruction of the coastal environment by inappropriate MSW disposal.* The Act clearly and simply forbids discharges of any kind (except stormwater or sanitary sewage) to navigable waters, as well as the deposition of any material into navigable waters or on their banks. The U.S. Army Corps of Engineers was authorized to set up a permitting program to allow discharges under limiting conditions.

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* It should be noted that the Refuse Act applies to both fresh and marine, and interstate and intrastate waters.

Although the Rivers and Harbors Act refers to navigable waters and obstructions to navigation, the Federal courts have consistently held that the prohibition against discharge of refuse was to be interpreted broadly. In one case, (U.S. vs. Standard Oil), the Supreme Court defined refuse as "all foreign substances and pollutants." In additon, navigability has been defined very broadly to include past, present, or potentially navigable waters, as well as freshwater marshes.

Despite this broad and clear mandate, the U.S. Army Corps of Engineers has not enforced the law vigorously. In 1970, there were fewer than 300 permits in effect.+ Subsequent to the creation of the EPA, a memorandum of understanding was agreed upon by EPA and the Corps to assign EPA regions with responsibility for investigating water pollution violations and for filling a report to the District Engineer on the violation, including recommendations for action.

Also in 1970, President Nixon issued Executive Order 11574, creating a specific permit program under the Rivers and Harbors Act. This program established compliance with water quality standards under The Clean Water Act as the decision criterion for permitting. However, the Corps of Engineers regulations that set up the program exempted dredge and fill activities. As a result, this potentially significant tool has not been applied to any great extent to control MSW disposal. Note that at least one Corps district has required permits for some disposal sites, although this seems to have worked primarily in terms of licensing established sites rather than of preventing or controlling pollution.

Clean Water Act

The 1972 and 1977 revamping of Federal water pollution control legislation failed (the Federal Water Pollution Control Amendments of 1972 (the Clean Water Act) and the 1977 Executive Orders on Floodplain Management and Protection of Wetlands) to recognize explicitly the serious pollution threat of improperly designed and operated MSW disposal facilities to coastal marine ecosystems. Under the Clear Water Act, direct discharges must meet effluent standards that limit the quantity of certain pollutant discharges so that certain receiving water quality criteria are not violated. Enforcement is through the National Pollution Discharge Elimination System. Every point source must obtain an NPDES permit, which sets conditions on the discharge so that the stricter of the two standards will be met. States with programs as strict as the Federal standards may administer their own programs (most states have chosen to do this). However, before enactment of regulations implementing the RCRA, MSW disposal sites

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+ The Refuse Act of 1899: New Tasks for an Old Law, 22 Hasting Law Journal 782-788, 1971.

were not considered to be point sources subject to these provisions. Alternatively, the Section 208 nonpoint source program has been oriented almost exclusively toward agricultural, residential, and stormwater runoff problems.

The U.S. Army Corps of Engineers, however, was granted authority to issue permits for discharges of dredged and/or fill material under Section 404 of the Act. Before 1977, the Corps applied this permit program exclusively to operations either removing or placing material into navigable waters. In 1977, however, new regulations were promulgated whereby the Corps assumed jurisdiction of dredging and filling in wetlands, as well. Coastal MSW disposal clearly falls within this jurisdiction.

The enforcement provisions of these regulations set up three classes of permits: Nationwide, general, and individual.

Nationwide Permits--

Certain activities are permitted (i.e., permission is granted without special application). These activities include:

1. The discharge of less than 500 cubic yards of material, before January 25, 1976, in other than navigable waters.
2. Filling of nontidal rivers, streams, and their impoundments, including adjacent wetlands that are located above the headwaters. (Headwaters is defined as the point on a nontidal stream above which the average flow is less than 5 cubic feet per second.)
3. Filling of natural lakes and adjacent wetlands smaller than 10 acres that are fed or drained by sources above the headwaters.
4. Filling of isolated natural lakes and adjacent wetlands smaller than 10 acres.
5. Filling of other nontidal waters not a tributary to interstate or navigable waters.
6. Installation of utility line crossing where no change in bottom contours occurs (when the activity does not include coffer dams or construction access roads).
7. Supplying material for bank stabilization when the area is less than 500 feet long and averages less than 1 cubic yard per running foot of bank.
8. Filling minor road crossing.
9. Placement of fill incidental to construction of bridges.

10. Repair of rehabilitation of currently serviceable or previously authorized fill.

Activities suitable for nationwide permits must meet certain conditions:

1. The activity cannot destroy a threatened or endangered species.
2. Material must be free from toxic pollutants.
3. Fill must not be subject to erosion and other nonpoint pollution.
4. The discharge must not be in a wild and scenic river system, either Federal or State.
5. The discharge cannot be in proximity to a public water supply intake or in an area of concentrated shellfish production.
6. The activity must not disrupt aquatic life indigenous to the waterbody.

General Permits --

The next level of permitting requires application and review by the district engineer. General permits are issued for activities judged to have a minimal impact on watercourses and wetlands. At least four classes of activities will be eligible for general permits, approval of which will be made as expeditiously as possible. These are:

1. Small stream crossings and logging roads
2. Minor road modifications
3. Small pile and timber piers
4. Minor soil and water conservation projects

This list may be expanded in the future, and criteria defining the four activities are expected soon.

Individual Permits --

All other dredge and fill activities require individual permits. In issuing these permits, the District Engineer will consider specific physical and environmental criteria; among these are conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use, navigation, recreation, water supply, water quality, energy needs, safety, food production, and the general needs and welfare of the people. Permits will not be granted unless their issuance is found to be in the public interest.

The results of our (national) questionnaire survey showed that the degree to which the 404 permit program was effectively implemented with regard to MSW disposal sites varied, but it was not generally high.

Executive Orders 11958 and 11990

These two parallel orders issued by President Carter state their purposes as avoidance of long-and short-term adverse impacts associated with development of floodplains and wetlands. Federal agencies are directed to avoid support of new construction or development in these areas where a practicable alternative exists. Although the 404 permit program is exempted, restrictions on new residential, commercial, and infrastructural growth in coastal wetlands and floodplains will tend to act against increased demand for MSW disposal sites in these areas.

Coastal Zone Management Act

Passage of the Coastal Zone Management Act of 1972 (PL-583) removed land use planning along our coastlines from a States-only regulatory scheme, and attempted to interject some degree of national coordination and prioritization of competing uses. The Act set up a voluntary State/Federal planning process whereby states developed individualized programs with Federal funding. The only requirement was that the management program so developed would, according to the National Oceanographic and Atmospheric Administration (NOAA) Office of Coastal Zone Management (OCZM), accomplish the following objectives:

1. Identify important resources, areas, and uses within a State's coastal zone requiring management or protection;
2. Establish a policy framework to guide decisions about appropriate resource use and protection;
3. Identify the landward and seaward boundaries of the coastal zone;
4. Provide for the consideration of the national interest in the planning for and siting of facilities that meet more than local requirements; and
5. Include sufficient legal authorities and organizational arrangements to implement the program and insure conformance to it.

By late 1979, two-thirds of the coastal States will have received OCZM approval of their proposed programs, and implementation is occurring. By early 1980, OCZM estimates that 75% of our shoreline will be protected. The following list, modified from an OCZM report (Office of Coastal Zone Management, 1979), describes the legal and institutional situation as of January, 1979:

A. States that have enacted comprehensive coastal zone management legislation:

California (San Francisco Bay)	(1965, 1969)
Oregon	(1971, 1973)
Rhode Island	(1971)
California	(1972, 1976)
New Jersey	(1973, segment)
North Carolina	(1974)
Hawaii	(1975, 1977)
Alabama	(1976)
Puerto Rico (Culebra)	(1976, segment)
Alaska	(1977)
South Carolina	(1977)
Louisiana	(1978)

B. States that have enacted shoreland zoning or other special purpose legislation:

Washington	(1971)
Delaware	(1971)
Texas	(1972, 1976)
Maine	(1973)
Florida	(1975, 1978)
Georgia	(1979)

C. States that have issued executive orders for implementation of OCZM program:

Delaware
Hawaii
Maine
Maryland
North Carolina
Rhode Island

D. States that have adopted memoranda of understanding between State agencies:

California (BCDC)
Maine
Maryland
Massachusetts
New Jersey
Rhode Island
South Carolina

E. States that have established new coastal zone management agencies or subunits (A) or management commissions (C) established:

Alabama	(C+A)
Alaska	(C+A)
California	(C)
Connecticut	(A)
Delaware	(A)
Florida	(A)
Georgia	(C)*
Louisiana	(C+A)
Maine	(A)
Maryland	(C)
Massachusetts	(A)
New Hampshire	(A)
New Jersey	(A)
New York	(A)
North Carolina	(C)
Oregon	(C)
Puerto Rico	(A)
Rhode Island	(C+A)
South Carolina	(C)

F. States that have established new advisory groups:

Alabama
Connecticut
Delaware
Maine
Maryland
Massachusetts

---

* Georgia has recently withdrawn from the program.

Florida
Hawaii
Louisiana
New York
North Carolina
Texas

G. States with intrastate regional coastal zone management groups established:

California
Florida
Maryland
Massachusetts
Washington

H. States with interstate coordination groups established:

New England (Coastal Task Force)
Mid Atlantic (Mid Atlantic Governors Regional Advisory Committee
Virginia/Maryland (Bi-State Committee on Chesapeake Bay)
Pacific Northwest (Sea Use Council)
Oregon/Washington (CREST)
Puerto Rico, Virgin Islands, Hawaii, Guam (Islands Coordination Group)

The impact of coastal zone management on MSW disposal siting will be felt to the extent that the States set up effective land use planning processes insulated from the political and financial exigencies of local decisionmaking. The program is clearly designed to influence coastal land uses toward those inseparably associated with the coast, recognizing that our coastline is a limited resource. To the extent that this goal is reached, MSW disposal in coastal saline environments will be restricted.

Resource Conservation and Recovery Act

The RCRA follows the basic State/Federal approach utilized by the Coastal Zone Management Act, the Clean Water Act and the Clean Air Act. It also specifically incorporates solid waste management into the existing regulatory framework of environmental statutes. The RCRA completely replaces the old Solid Waste Disposal Act, and despite its name, concentrates almost entirely on solid waste disposal rather than on waste stream reduction and recycling. The relevant objectives of the Act include:

1. Providing technical and financial assistance to States to develop management plans that utilize improved waste management techniques and environmentally safe ultimate disposal;

2. Prohibition of open dumps and upgrading of existing facilities;

3. Promulgation of solid waste disposal guidelines.

Under the Act, municipal solid waste is defined broadly to include any waste material other than sewage, irrigation return water, and waste from industrial point sources. Disposal is defined as the act of placing solid waste on land or in water so that it enters the environment. Subtitle D prohibits MSW (and all other nonhazardous solid waste) disposal at any facility that does not meet RCRA criteria, and it requires closing and upgrading of all open dumps (facilities not meeting the criteria) within a relatively short time. Although the Act does not specify the criteria that EPA is charged with promulgating, it does require that those criteria achieve a general performance standard (i.e., that there is no reasonable probability of adverse effects on health or the environment).

The criteria for classification of solid waste disposal facilities take the form of performance standards in that they specify the level of environmental protection that must be achieved without specifying design techniques or disposal technologies. For a State program to be accepted by EPA, the standards must achieve equal or greater level of protection. Several environmentally sensitive areas (e.g., wetlands, floodplains, permafrost, critical habitats, and sole source aquifers) are defined, and disposal is severely restricted in these areas. For our purposes, wetland and floodplain restrictions are relevant. A solid waste disposal facility cannot be located in a wetland without a thorough discussion of alternatives, and an NPDES permit is required. EPA notes that there will be a strong presumption against permitting such a site without a showing of "extraordinary circumstances." Facilities in floodplains must be protected against inundation by the 100-year flood, and they must not adversely affect upstream or downstream flooding. The net effect of these two provisions will be to make coastal marine sites less attractive from both a cost and a red-tape point of view.

EPA has also issued technical guidelines that further refine the criteria and provide discussions of acceptable disposal technologies and design methods to achieve the performance standards of the criteria. The guidelines recognize that if no feasible alternative exists, disposal in environmentally sensitive areas will occur. They describe alternative engineering design and operational methods to minimize environmental pollution. Leachate control by low permeability barriers, soil attenuation, and diversion of surface runoff is described. Gas and runoff control on the landfill are covered, as well as daily operational and monitoring guidelines. The requirements of the criteria and guidelines are summarized in Table 4.

Impact Of Federal Regulations

From the regulatory analysis performed above, it is clear that before enactment of the RCRA, siting, design, and operation of MSW disposal facilities were primarily regulated at the State or local level of government. Federal involvement was peripheral in that the definitions and enforcement criteria occasionally were written so that they could be applied to MSW disposal. Because of budgetary constraints and policy decisions, even those programs that could potentially have been brought to bear on the problem (e.g., Section 404, permitting) rarely were. Improper MSW disposal was not considered to be a national problem, but at worst, an aesthetic or nuisance problem.

Final promulgation and enforcement of the RCRA regulations will produce a dramatic turnaround. The environmental as well as the aesthetic and nuisance impacts of landfills will be (have been) recognized as engineering

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TABLE 4. FEDERAL CRITERIA AND PERFORMANCE STANDARDS FOR MSW DISPOSAL FACILITIES

Location	Design	Operation	Performance
1. Avoid environmentally sensitive areas unless no feasible alternative a. Wetlands b. 100-year floodplains c. Permafrost areas d. Critical habitats e. Sole source aquifer recharge zones 2. Avoid active fault zones & karst terrain unless there is a minimal potential for adverse effects 3. Environmentally acceptable sites should be cost effective 4. Potential incorporation into regional solid waste system is to be considered 5. Reject sites traversed by pipes or conduits 6. Soil should be adequate for cover and mobility 7. Avoid bird hazards near airports 8. Sites should be accessible in all weather via public roads 9. Aesthetics, safety, litter, noise and other nuisances are to be considered	1. Landfill design should be based on: a. Type & volume of wastes b. Current & projected water use c. Existing water quality in area of influence d. Depth to water table and rate of groundwater flow e. Potential interactions with area hydrogeology f. Site geology (hydraulic conductivity and soil g. Presence/absence of floodplain h. Prevention of water balance and leachate i. Tradeoff analysis between environmental, economic, waste stream and future use factors j. Existing & final topography k. Land use & zoning surrounding site 2. Leachate should be controlled by: a. Allowing 1.5 meters from bottom of fill to seasonal high water table b. Controlling hydraulic connection between landfill & surface water c. Providing surface runoff diversion to handle 10 year, 24-hour event d. Providing final cover to slope between 2% and 3% e. Vegetating final cover 3. Cover material should balance: a. Trafficability b. infiltration control c. Gas migration control d. Fire resistance e. Erosion control f. Vector control g. Vegetative growth	1. Wastes not compatible with site design, location, or operation are not accepted 2. No hazardous waste is accepted 3. Design may require prohibition/pretreatment of some wastes (liquids, semisolids or sludge) 4. Cover matter should be applied (minimum 6 in. daily) 5. Cells inactive for 3 or more months require 12 in. cover 6. Completed landfill to be covered with 6 in. clay or equivalent and at least 8 in. soil 7. Volume reduction by compaction, baling, or shredding is usually necessary 8. No open burning is permitted 9. Hard hats, gloves, goggles, etc., are required for site workers 10. Safety devices are required on equipment 11. Fire and emergency communications equipment is required 12. Scavenging is prohibited 13. Site access may be given only when operating personnel are present 14. Water to control dust/fire is necessary 15. Groundwater monitoring should be conducted before operation & at least 1 year thereafter 16. Explosimeter monitoring should be provided for gases in buildings 17. Regular perimeter soil gas monitoring should be provided	1. There should be no reasonable probability of adverse effects on health or the environment 2. No adverse effect on surface water quality should occur 3. No degradation of drinking water or other groundwater with 10,000 mg/l dissolved solids should occur beyond site boundaries 4. No degradation of groundwater not designated for drinking should occur off-site(i.e., it must meet State limits for intended use). 5. Air emissions must comply with State, Federal & local air pollution regulations 6. No open burning is permitted 7. Disease vectors should be controlled by periodic cover application 8. Explosive gases in structures on soil at boundary must be kept below lower explosive limits 9. Toxic or asphyxiating gases must be kept below harmful levels & not allowed to migrate offsite 10. Fires must be extinguished & hazards minimized 11. Access should be controlled to minimize hazards to the public

(continued)

TABLE 4 (continued).

Location	Design	Operation	Performance
	4. If leachate attenuation is insufficient, line site with clay or synthetics, with or without collection system 5. Leachate disposal should be in accordance with Sec. 402 of the Clean Water Act: chemical, physical, biological, or land treatment maybe used, as appropriate 6. In fills designed to reduce infiltration, gas venting is necessary 7. Passive or active gas cutoff should be used to a distance 10 times the maximum fill depth 8. Runoff should be controlled by: a. Diversion by berms, dikes, and ditches b. Grade cover to minimize runoff while controlling erosion c. Well compacted, finegrained soils for final cover d. Passing of uncontaminated runoff through a settling basin		

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problems that can be overcome with careful siting, design and operation. Solutions will not be achieved without substantial cost, however. According to the draft environmental impact statement on the guidelines, the existing national range will be $4 to $11 per ton.

The positive environmental impacts achieved in terms of coastal MSW disposal will be large. The siting criteria will eliminate destruction of important productive saltwater and estuarine wetlands wherever feasible alternatives exist. The design and operational guidelines will help to ameliorate and/or prevent any impacts beyond habitat depletion. Control of leachate production coupled with containment and/or treatment will drastically reduce the volume of leachate discharged to coastal marine ecosystems. Although this volume may be small, compared to water volumes in the littoral zone, it could produce subtle, low-level impacts that could escape detection and later become long-term problems. And even though the volume of leachate discharged is small, the cost of treatment and retrofit is sure to greatly exceed proper initial disposal, perhaps by many orders of magnitude.

STATE CONTROL

Levels of MSW Control

The laws and regulations of the coastal States vary considerably in their levels of control over the disposal of MSW in estuarine and coastal marshlands. The laws of each State that might relate to MSW disposal were examined for applicability, permit requirements, enforcement measures, penalties for violation, and disposal criteria. This information was compiled into the following series of tables.

Table 5 is a brief overview of the relevant laws of each coastal State. It includes the dates of enactment, amendment dates, purposes, types of effect on solid waste disposal (i.e., direct or indirect), and the regulatory authority or administering agency. Direct effects are defined as those that would control performance. Indirect control is that exerted over the disposal of solid waste in coastal areas through laws governing water pollution, siting, coastal activity, or land use.

Table 6 shows the requirements necessary in each State to obtain a permit for operation of a solid waste disposal facility.

The enforcement measures available in each State and the penalties for violation of the laws that relate to solid waste disposal are described in Table 7. These differ considerably and give a good indication of the State's power to enforce regulations and thereby control pollution that may be caused by environmentally hazardous solid waste disposal practices. Table 8 is a summary version that provides a quick overview of pollution control laws and the extent of civil and criminal penalties in each coastal State.

Table 9 indicates the location, design, and operation criteria and performance standards under which the sanitary landfill method of solid waste disposal must operate. As can be seen, there is a great deal of variation. In some cases, no particular criteria are given other than to operate in an efficient and economical manner. In other instances, day-to-day operations are regulated in great deal. An analysis of the varying levels of control exerted by the coastal States follows these tables.

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TABLE 5. STATE LAWS AND/OR REGULATIONS AFFECTING SOLID WASTE DISPOSAL

Statutes and/or Regulations	Date of enactment	Amended through	Purpose	(Effect (direct or indirect)	Administering Agency
Alabama:					
Alabama Solid Wastes Disposal Act	1969	1971	To manage the disposal of solid waste. Establish solid waste management programs.	D*	Alabama State Department of Public Health, County Health Board
Alabama Solid Wastes Management Regulations	7/72	1972	To establish rules and regulations for managing solid waste: Protect Public Health.	D	Alabama State Department of Public Health
Alabama Standards for Disposal of Solid Wastes	6/69	1969	To establish standards for the disposal of solid waste meeting health, conservation and aesthetic requirements.	D	Alabama State Department of Public Health
Alabama Water Pollution Control Act	9/71	1973	To conserve waters of State: Protect, maintain, and improve quality of waters.	I†	Water Improvement Commission
Alabama Water Quality Criteria	5/67	1977	Same as above - to establish water criteria, maintain higher than quality water except as necessary for social and economic development.	I	Water Improvement Commission
Alabama Waste Discharge Permit Policies and Procedures	1,2,8/72	1972	To establish policies and procedures for waste discharge permits.	I	Water Improvement Commission
Alaska:					
Alaska Department of Environmental Conservation Act	7/71	1971	To establish Department of Environmental Conservation to develop policies, rules, and regulations to conserve environment and prevent pollution.	I	Alaska Department of Environmental Conservation
Alaska Solid Waste Management Regulations	7/73	1973	To manage solid waste to control, prevent, and abate pollution of the air, water, land, and subsurface land of the State.	D	Alaska Department of Environmental Conservation
Alaska Water Quality Standards	10/72	8/73	To establish water quality standards for waters of state; maintain higher than established quality standards, except as necessary for social or economic reasons.	I	Alaska Department of Environmental Conservation

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* Direct effects (those that would control source aspect of the disposal facility's location, design, operation, or performance).

† Indirect effects (those that would control solid waste disposal in coastal areas - through laws governing water pollution, siting, coastal activity, or land use).

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purpose	Effect (direct or indirect)	Administering Agency
Alaska Wastewater Disposal Regulations	8/73	2/77	To establish regulations protecting ground and surface waters from pollution caused by wastewater disposal.	I	Alaska Department of Environmental Conservation
California:					
California Solid Waste Management and Resource Recovery Act of 1972	1972	1976	To establish and maintain a solid waste management plan to manage solid waste so as to protect the public and the environment, and to maximize resource recovery.	D	Solid Waste Management Board, Department of Public Health
California Coastal Acts	9/76	1976	To maximize the benefits of the coastal zone while preserving and protecting it.	I	California Coastal Commission
California Water Pollution Control Laws	---	12/77	To conserve, control, and utilize water resources of the State considering economic, social, and environmental impacts.	I	State Water Resources Control Board
California Water Regulations	---	2/79	To control, prevent, and abate water pollution in general, and specifically that caused by solid waste disposal on land.	D	State and Regional Water Resources Control Board
Connecticut:					
Connecticut Solid Waste Management Act	1973,1974 1975,1976	1978	To manage solid waste to protect public health, and environment, and to preserve and protect natural resources.	D	Department of Environmental Protection
Connecticut Solid Waste Management Regulations	1975	1975	To establish regulations for the management of solid waste disposal	D	Department of Environmental Protection
Connecticut Clean Water Act	1967	1977	To control, prevent and abate water pollution.	I	Water Compliance Unit of Environmental Protection
Connecticut Water Quality Standards	10/73	9/77	To establish standards of water quality for waters of the State.	I	Department of Environmental Protection
Connecticut Tidal Wetlands Act	1969	1977	To preserve and protect tidal wetland areas.	I	Department of Environmental Protection
Delaware:					
Delaware Solid Waste Authority Act	8/75	7/76	To establish a statewide solid waste management plan. To protect the environment from improper solid waste disposal and to maximize resource recovery.	D	Delaware Solid Waste Authority

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purpose	Effect (direct or indirect)	Administering Agency
Delaware Solid Waste Disposal Regulations	8/74	1974	To establish regulations for the management of solid waste.	D	Delaware Solid Waste Authority
Delaware Coastal Zone Act	6/71	1971	To control the location, extent, and type of industrial development in coastal areas to protect the natural areas for recreation and tourism.	I	Delaware State Planning Office
Delaware Wetlands Act	7/73	1973	To preserve and protect the productive public and private wetlands and to prevent their despoliation and destruction consistent with the historic right of private ownership of lands.	I	Department of Natural Resources and Environmental Control
Delaware Water Quality Standards	5/74	4/75	To establish water quality criteria.	I	Department of Natural Resources and Environmental Control
Delaware Water Pollution Control Regulations	3/74	3/75	To insure that surface and groundwater are maintained at established criteria.	I	Department of Natural Resources and Environmental Control
Florida:					
Florida Resource Recovery and Management Act	---	---	To plan for and regulate solid waste disposal and recycling, to establish a State program of planning for resource recovery, and to promote resource recovery systems that enhance air, water, and land resources.	D	Department of Environmental Regulation
Florida Resource Recovery and ment Act of 1972	Part I: Oct. 1, 1974	4/75 7/76	To plan for disposal and recycling of solid waste, to protect the public safety, health, and welfare, and to enhance the environment.	D	Florida Department of Pollution Control
Florida Environmental Land and Water Management Act of 1972	7/72	7/74	To protect the natural resources and environment, to reverse the deterioration of water quality, and to establish land and water management policies to protect the public's health, welfare, safety, and quality of life.	I	Division of State Planning Department of Administration
Florida Beach and Shore Preservation Act	9/71	1971	To preserve the beaches and shoreline and to regulate the construction and reconstruction of structures below the mean high waterline of any tidal water.	I	Department of Natural Resources
Florida Air and Water Pollution Control Act	1969	1977	To prevent, abate and control pollution of the air and water.	I	Department of Environmental Regulation

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purpose	Effect (direct or indirect)	Administering Agency
Florida Rules on Pollution of Waters	1970	6/76	To establish water quality standards, and to maintain higher than quality water except as necessary for social and economic development.	I	Department of Environmental Regulation
Georgia:					
Georgia Solid Waste Management Act	4/72	4/73	To provide for solid waste management to protect the public health, safety, and well-being of its citizens, and to protect and enhance the quality of the environment.	D	Division of Environmental Protection, Department of Natural Resources
Georgia Solid Waste Management Rules	12/72	10/74	To manage solid waste through regulations, permit requirements, and management plans.	D	Department of Natural Resources, Division of Environmental Protection
Georgia Coastal Marshlands Protection Act	1970	1977	To establish the Coastal Marshlands Protection Agency and its powers and duties to regulate activities in the estuarine marshlands.	I	Coastal Marshlands Protection Agency
Georgia Water Quality Control Act	1966	1977	To restore and maintain the quality of the waters of the State. To prudently use the State's water resources.	I	Department of Natural Resources, Division of Environmental Protection, State Water Quality Control Board
Georgia Water Quality Control Regulations and Water Use Classifications	6/74	2/78	To establish regulations governing water quality control.	I	Department of Natural Resources, Division of Environmental Protection, State Water Quality Control Board
Hawaii:					
Hawaii Environmental Quality Law	5/72	1974	To prevent, control, and abate solid waste pollution.	D	Office of Environmental Quality Control
Hawaii Solid Waste Ownership Act	6/76	1976	To define the ownership of the State's solid waste to avoid legal complications.	D	Office of Environmental Quality Control.
Hawaii Solid Waste Management Control Regulations	7/74	1974	To establish minimum standards for design of solid waste disposal systems to prevent air and water pollution, to protect the public health and safety natural resources, and to enhance the environment.	D	Department of Health

(continued)

TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purpose	Effect (direct or indirect)	Administering Agency
Hawaii Water Pollution Control Regulations	1/68	1975	To conserve, protect, maintain, and improve the quality of the waters of the State. To maintain higher than quality water except as necessary for social and economic development.	I	Department of Health
Louisiana:					
Louisiana Solid Waste Laws	1950	7/77	To create greater efficiency and economy in solid waste disposal service and to prevent health hazards.	D	State Board of Health
Louisiana Solid Waste Regulations	1/68	1968	To provide guidelines for the disposal of garbage and other refuse to prevent health hazards.	D	Louisiana Department of Health
Louisiana Water Quality Criteria	8/73	1977	To establish standards of water quality and to maintain higher than quality water except as necessary for social and economic development.	I	Louisiana Stream Control Commission. Division of Water Pollution Control of the Wildlife and Fisheries Commission.
Louisiana Stream Control Commission Acts	-	1975	To establish the commission and its duties; to prevent and control water pollution.	I	Stream Control Commission.
Maine:					
Maine Solid Waste Management Act	10/73	1975	To preserve and protect the environment through management of solid waste disposal.	D	Department of Environmental Protection
Maine Solid Waste Management Regulations	7/75	2/1976	To establish regulations in order to preserve and protect the environment through management of solid waste disposal.	D	Department of Environmental Protection
Maine Land Use Law	10/73	1975	To manage land use in order to protect the environment and the public health and welfare.	D	Maine Land Use Regulation Commission.
Maine Site Location Act	1970	1975	To control the location of development in order to protect the public health and welfare and the environment.	D	Maine Board of Environmental Protection.
Maine Coastal Wetlands and Zoning Law	1970	1975	To manage development in the coastal wetlands in order to protect the public health and welfare and the environment.	I	Maine Board of Environmental Protection.
Maine Water Pollution Control Law	1975	9/78	To preserve the waters of the State. To prevent, control and abate water pollution. To establish water quality standards.	I	Maine Board of Environmental Protection.

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purpose	Effect (direct or indirect)	Administering Agency
Maine Water Quality Control Regulations	9/72	1974	To establish regulations for the maintenance of water quality.	I	Maine, Bureau of Water Quality Control Regulations
Maryland:					
Maryland Solid and Hazardous Waste Laws	-	1978	To manage solid and hazardous waste disposal in order to protect the public health and welfare and the environment.	D	Department of Health and Mental Hygiene
Maryland Water Pollution Control Laws	-	1970	To control, prevent, and abate water pollution, to protect the public health & welfare.	I	Environmental Health Services within State Department of Health
Maryland Water Resources Law	6/74	1974	To establish the Water Resources Administration for the management of the State's water resources.	I	Water Resources Administration within Department of Natural Resources
Maryland Environmental Service Act of 1970	7/70	1973	To establish a service to provide a water supply waste purification and disposal in compliance with State law governing air, land, and water pollution.	I	Maryland Environmental Service
Maryland Water Pollution Control Regulations	9/74	4/78	To establish water quality standards and effluent limitations to protect the legitimate uses of the State's water.	I	Water Resources Administration
Maryland Discharge Permits Regulation	9/74	4/78	To establish procedures for discharge permits.	I	Water Resources Administration
Maryland Water Pollution Control Principles	9/74	4/78	To establish principles for decision-making in order to improve, conserve and manage the quality of the waters of the State.	I	Water Resources Administration
Maryland Groundwater Quality Standards	9/74	1974	To establish water quality standards for the State's groundwater.	D	Water Resources Administration
Maryland Water Quality Standards	9/74	7/78	To establish water quality standards for the State's surface water.	I	Water Resources Administration
Massachusetts:					
Massachusetts Solid Waste Disposal Law	-	1978	To establish a bureau to manage the disposal of solid waste.	D	Bureau of Solid Waste Disposal within Department of Environmental Management

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Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
Massachusetts Wetlands Protection Laws	1965 1967	1976	To manage and protect wetlands.	I	Wetlands Division within the Department of Environmental Quality Engineering
Massachusetts Sanitary Landfill Regulations	4/71	1971	To establish regulations for the sanitary landfill method of solid waste disposal.	D	Department of Public Health
Massachusetts Clean Water Act	1966	1975	To establish a water pollution control plan in order to control, abate, and prevent water pollution.	I	Division of Water Pollution Control, Water Resources Commission
Massachusetts Water Quality Standards	9/78	2/79	To establish water quality standards for the waters of the State.	I	Department of Environmental Quality Engineering
Mississippi:					
Mississippi Solid Waste Disposal Act of 1974	4/74	1976	To establish a solid waste management plan.	D	State Health Department
Mississippi Solid Waste Regulations	1971	1971	To regulate the accumulation and disposal of solid waste.	D	State Health Department
Mississippi Sanitary Landfills Standards	1971	1971	To establish standards for the sanitary landfill method of solid waste disposal.	D	State Health Department
Mississippi Air and Water Pollution Control Act	1942	1977	To prevent, abate and control air and water pollution in order to protect the public health and welfare and the environment.	I	Air and Water Pollution Control Commission
Mississippi Water Quality Criteria	4/73	4/77	To establish water quality standards and maintain higher than quality water except as necessary for social and economic development.	I	Air and Water Pollution Control Commission
Mississippi NPDES Regulations	5/74	3/75	To establish regulations in order to implement the NPDES program.	I	Air and Water Pollution Control Commission
Mississippi Coastal Wetlands Protection	-	1974	To preserve and protect the coastal wetlands of the State.	I	Mississippi Marine Resources Council

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
New Hampshire:					
New Hampshire Waste Disposal Laws	-	3/72	To provide for the management of solid waste disposal.	D	New Hampshire Department of Health and Welfare, Div. of Public Health Services
New Hampshire Water Pollution Control Law	-	1975	To establish the powers and duties of the Commission and the general standards of surface water quality for the State.	I	Water Supply and Pollution Control Commission
New Hampshire Water Quality Standards	4/77	1977	To establish water quality standards for the waters of the State.	I	Water Supply and Pollution Control Commission
New Jersey:					
New Jersey Solid Waste Laws	5/70	1976	To establish a solid waste management and resource recovery plan.	D	Department of Environmental Protection
New Jersey Waste Control Act	1973	1974	To control and regulate the treatment and disposal of solid and liquid waste.	D	Department of Environmental Protection
New Jersey Solid Waste Management Regulations	6/74	7/77	To establish rules for the regulation of registration, operation, and maintenance of sanitary landfills, hauling, and other disposal methods.	D	Bureau of Solid Waste Management
New Jersey Coastal Area Facility Review Act	9/73	1973	To establish a review process for coastal area development.	I	Dept. of Environmental Protection
New Jersey Department of Environmental Protection Act of 1970	1972	1975	To establish the powers and duties of the Dept. of Environmental Protection.	I	Dept. of Environmental Protection
New Jersey Water Pollution Control Laws	4/77	1977	To restore and maintain the quality of the State's water.	I	Dept. of Environmental Protection
New Jersey Water Quality Planning Act	4/77	1977	To establish a plan for the maintenance and restoration of the State's water quality.	I	Dept. of Environmental Protection
New Jersey Wetlands Act of 1970	1970	1970	To provide for the protection of natural resources in coastal wetlands.	I	Dept. of Environmental Protection
New Jersey Water Pollution Control Regulations	7/77	3/78	To prevent, control and abate water pollution.	I	Dept. of Environmental Protection
New Jersey Surface Water Quality Standards	12/74	1/78	To establish surface water quality standards for the waters of the State.	I	Division of Water Resources

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
New York:					
New York Environmental Conservation Law, Article 27	1972,1973, 1975,1977	1977	To manage solid waste efficiently and to develop a solid waste management and resource recovery plan.	D	N. Y. Dept. of Env. Conservation
N.Y. Solid Waste Management Facilities Rules	5/77	1977	To regulate solid waste management facilities to prevent pollution.	D	N.Y. Dept. of Env. Conservation
N.Y. Wetlands Law - Env. Cons. Law - Article 25	6/73	1976	To preserve wetlands in their natural state and abate and remove sources of their pollution.	I	N.Y. Dept. of Env. Conservation
N.Y. Classifications & Standards	9/72	9/74	To establish a statewide classification system and water quality standards.	I	N.Y. Dept. of Env. Conservation
N. Y. Rules on Use and Protection of Waters	5/72	1972	To establish permit procedures and regulations for activities using the waters of the State.	I	N.Y. Dept. of Env. Conservation
Tidal Wetlands Land Use Regulations	8/77	1977	To establish regulations to implement Article 25: New York Wetlands Law.	I	N.Y. Dept. of Env. Conservation
N. Y. Uniform Procedures, Statutory Authority; ECL Section; 70-0107	-	-	To establish application and permit procedures for actions affecting by the Env. Conser. Law.	D	N.Y. Dept. of Env. Conservation
N. Y. Environmental Conservation Law Article 17-Water Pollution Control	9/72	1977	To preserve and protect the waters of the State by control prevention and abatement of water pollution.	I	N.Y. Dept. of Env. Conservation
N. Y. Regulations on State Pollutant Discharge Elimination System	8/75	1975	To establish regulations to implement the State pollutant discharge elimination system.		N.Y. Dept. of Env. Conservation
North Carolina:					
N.C. Solid Waste Disposal Law	1969	6/78	To establish a solid waste management and recovery plan in order to prevent pollution.	D	N.C. State Board of Health
N.C. Solid Waste Disposal Regs.	3/71	4/76	To establish rules for the collection, transport, storage, and disposal of solid waste.	D	N.C. State Board of Health
N.C. Env. Policy Act of 1971	7/71	1977	To declare a State policy encouraging the wise productive and beneficial use of the natural resources of the State.	I	Any agency involved in environmental decisions
N.C. Surface Water Classifications and Water Quality Standards	2/76	3/77	To establish surface water classifications and water quality standards. To maintain higher than quality water except as necessary for social and economic reasons.	I	Environmental Management Commission

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Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
N.C. Wastewater Discharge Permit Regs.	2/76	1976	To establish regulations for permits controlling sources of water pollution.	I	Env. Management Commission of the Dept. of Natural & Economic Resources
Oregon:					
Oregon Solid Waste Control Law	1969	1977	To manage solid waste disposal to protect the public health and welfare and the environment.	D	Dept. of Environmental Quality
Oregon Solid Waste Regulations	4/71	9/74	To establish requirements, limitations, and procedures for storage, collection, transportation and disposal of solid waste.	D	Dept. of Environmental Quality
Oregon Land Use Law	10/73	1973	To provide for properly prepared and coordinated plans for land use.	I	Land Conservation & Development Commission
Oregon Land Use Goals and Guidelines Regulations	1/75	12/75	To establish guidelines to be followed for land use development plans.	D	Land Conservation & Development Commission
Oregon Water Pollution Control Laws	1969	1977	To conserve the waters of the State and to protect, maintain, and improve their quality.	I	Dept. of Environmental Quality
Oregon Water Quality Control Regs.	6/74, 12/71, 2/72, 6/67, 6/76	1976	To establish regulations in order to conserve the waters of the State and to protect, maintain, and improve their quality.	I	Dept. of Environmental Quality
Puerto Rico:					
Puerto Rico Water Pollution Control Law	5/50	1950	To designate the Department of Health as the agency responsible for the prevention and abatement of water pollution.	I	Puerto Rico Dept. of Health
Puerto Rico Public Policy Environmental Act	7/70	1974	To establish a Board of Environmental Quality to protect the health and welfare of the public.	I	Board of Env. Quality
Puerto Rico Water Quality Standards	1/74	11/76	To establish regulations in order to preserve, maintain, and enhance the quality of the waters of Puerto Rico except as is socially or economically necessary.	I	Board of Env. Quality
Rhode Island:					

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TABLE 5 (continued).

Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
R.I. Solid Waste Law	7/68	1974	To manage the disposal of solid waste.	D	Div. of Solid Waste Management of the R.I. Dept. of Health
R.I. Solid Waste Management Regulations	3/75	1975	To establish regulations to minimize environmental hazards associated with solid waste transfer, resource recovery, and disposal facilities.	D	R.I. Dept. of Health
R.I. Coastal Resources Management Council	1971	1973	To establish a council responsible to preserve, protect, develop, and restore the coastal area.	I	Div. of Coastal Resources of the Dept. of Natural Resources
R.I. Solid Waste Management Corporation Act	7/74	1974	To establish a distinct public corporation to manage solid waste disposal and resource recovery in order to prevent degradation of the environment.	D	R.I. Solid Waste Management Corp.
R.I. Solid Waste Management Facility Licenses	12/75	1975	To establish regulations for the design and operation of sanitary landfills and resource recovery facilities.	D	R.I. Dept. of Health
R.I. Water Pollution Control Law	1956	1974	To establish the powers and duties of the Div. in order to prevent, abate, and control water pollution.	I	Div. of Water Supply & Pollution Control of the State Dept. of Health
R.I. Water Quality Standards	1967	12/77	To establish standards of water quality and to maintain higher than quality water except as necessary for social or economic reasons.	I	Div. of Water Supply and Pollution Control
South Carolina:					
S.C. Landfill Regulation	9/71	1971	To provide for the safe and efficient operation of sanitary landfills as means for the disposal of solid waste.	D	State Board of Health
S.C. Industrial Solid Waste Disposal Site Regulation	3/72	1972	To regulate indirect pollution of air and water caused by improper disposal of solid waste.	D	S.C. Pollution Control Authority
S.C. Guidelines for Waste Disposal Permits	9/72, 2/73	1973	To establish guidelines for the disposal of inert or hazardous wastes.	D	S.C. Pollution Control Authority
S.C. Pollution Control Acts	1971	1975	To provide for the creation of the Pollution Control Authority in order to control pollution.	I	Dept. of Health and Env. Control

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Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
S.C. Classification Standards	9/71	4/77	To establish water quality standards and to maintain higher than quality standards except as necessary for social or economic reasons.	I	Dept. of Health and Env. Control
Texas:					
Texas Solid Waste Disposal Act	1969	1977	To control the collection, handling, storage and disposal of solid waste in order to protect the health, welfare and physical property of the public.	D	Texas State Dept. of Health
Texas Solid Waste Regulations	2/76	4/77	To establish regulations for control of the collection, handling, storage and disposal of solid waste.	D	Texas State Dept. of Health
Texas Water Quality Act	9/77	1977	To establish the powers and duties of the Dept. in order to prevent water pollution.	I	Texas Dept. of Water Resources
Texas Water Quality Rules	3/70	5/77	To establish regulations in order to control and abate pollution of the waters of the State.	I	Texas Dept. of Water Resources
Texas Water Quality Standards	1973	1976	To establish standards of water quality.	I	Water Quality Board
Virginia:					
Virginia Solid Waste Disposal Law	-	1974	To establish mechanism for developing State solid waste plan.	D	Health Dept., Bureau of Solid Waste & Vector Control
Virginia Solid Waste Regulations	1971	1971	To regulate the disposal of solid waste.	D	Health Dept., Bureau of Solid Waste and Vector Control
Virginia State Water Control Law	1973	8/78	To restore and maintain the quality of waters of the State. To control, abate, and prevent pollution and to manage State water resources.	I	State Water Control Board
Virginia Discharge Permit Regulations	1975	1975	To establish a permit system for the regulation of discharges into the waters of the State.	I	State Water Control Board
Virginia Water Quality Standards	7/70	10/74	To establish standards of water quality for the waters of the State.	I	State Water Control Board

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Statutes and/or Regulations	Date of enactment	Amended through	Purposes	Effect (direct or indirect)	Administering Agency
Washington:					
Washington Solid Waste Management Law	-	-	To establish a solid waste management plan that will conserve resources and prevent pollution.	D	Dept. of Ecology
Washington Solid Waste Handling Regulations	10/72	11/72	To establish minimum regulations for the handling and disposal of solid waste.	D	Dept. of Ecology
Washington Shoreline Management Act of 1971	6/71	1977	To provide for the management and protection of the State's shoreline.	I	Dept. of Ecology; Local Government
Washington Shorelines Development Permit Regulations	1/72	7/76	To establish rules for the permitting system.	I	Dept. of Ecology
Washington Water Pollution Control Laws	1971	1973	To insure the highest possible purity of State waters and to control, abate, and prevent pollution.	I	Dept. of Ecology
Washington NPDES Permit Program Regulations	2/74	5/76	To establish a permit program to control discharges of pollutants into the navigable waters of State.	I	Dept. of Ecology

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TABLE 6. REQUIREMENTS FOR OBTAINING A PERMIT TO OPERATE A SOLID WASTE DISPOSAL FACILITY

State	Requirements	Duration of permit
Alabama	1. Site and operational plan must be approved by Department. 2. Approval (approval=permit) based on judgment of Health Department and Alabama Geological Survey.	1 year
Alaska	The following must be submitted to the department for approval: 1. Application form. 2. Plans and specifications for facility. 3. Certification of compliance with local and zoning requirements. 4. Detailed information of operation, type of waste, population and area to be served, distribution of reprocessed material, disposal of residue, type and amount of equipment, proposed ultimate land use plan.	5 years
California	1. Operator must be authorized by Board. 2. Permit requirements must be consistent with the county solid waste management plan or State standards. 3. Local agencies must certify that they have approved site. 4. Enforcement agency or Board may require technical or monitoring program reports or other reports as specified. 5. Report must be submitted detailing: a. Topographic information b. Geohydrologic information c. Type and amount of waste d. Operational plan e. Pollution control plan f. Land use after closure of site	5 years
Connecticut	1. Qualifications of operator are subject to approval by Commissioner. 2. Plan and design and method of operation must be filed with Commissioner. 3. Permit must be filed in land records. 4. Permit application must be made on department forms, including all information required by most current guidelines: a. Engineering information b. Operation and management plan c. Geohydrologic information d. Type and amount of waste e. Pollution control plan f. Anticipated land use plan 5. Permit application must be consistent with 20-year solid waste management plan.	At discretion of Department
Delaware	1. Engineering design plans must be formulated to include: a. Hydrogeological information b. Locational information c. Pollution control methods 2. Operational plans must be formulated showing amount and type of waste, method of disposal, type of cover. 3. Certification of local zoning approval must be provided. 4. Ultimate land use plans must be submitted. 5. Contingency plans of operation required. 6. Fire and vector control plan required.	
Florida	1. Operation permit will be issued to operating facilities when facility meets all criteria. 2. Plans prepared by a Professional Engineer (Florida Registered) must be submitted including: a. Topographic information b. Hydrogeological information c. Operational plan (type of waste, area served) d. Final land use	3 years at the discretion of Department

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TABLE 6 (continued).

State	Requirements	Duration of permit
Georgia	1. Plans, specifications and information as required must be submitted in accordance with rules and regulations. 2. Permits shall be on forms prescribed by Division. 3. Information as requested by Division must be submitted so as to ascertain the effect on the environment.	At discretion of Division
Hawaii	1. Completed application form must be furnished by the Director, including: a. Detailed plans and specifications for facility b. Certification of compliance with local ordinances and zoning requirements c. Operations plan report, including: 1. Proposed method of operation 2. Population and area to be served 3. The use and distribution of processed waste 4. Method of processed residue disposal 5. Type and amount of equipment 6. Proposed ultimate use of disposal site 2. Solid waste facility should be designed, built and equipped with best practicable technology so as to operate without causing a violation of rules and regulations.	5 years
Louisiana	1. No reference is made to permit, but plans for solid waste disposal facility must be approved by State Board of Health.	No reference to permit
Maine	1. Requirements for permits are developed by Board. 2. Plans for solid waste facilites are subject to approval by Board to assure compliance with rules and regulations, and they should include descriptions of the following: a. Topographic information b. Hydrogeologic information c. Design information d. Operational information	At discretion of Board
Maryland	1. Complete plans and specifications for installation, alternation, or extension must be approved. 2. Other additional information, as required, must be submitted to department.	At discretion of Department
Massachusetts	1. Plans designed by a registered engineer must be approved by Department of Public Health. 2. Application must include: a. Topographic information b. Geohydrologic information c. Restoration plan d. Methods of operation e. Methods of pollution prevention 3. Approved plan must be submitted to Department of Natural Resources for wetland consideration.	1 year
Mississippi	1. Requirements are to be established by the State Board of Health. 2. Detailed operational plan must be approved.	1 year
New Hampshire	1. Plans must be submitted for approval, including: a. Specifications of facility b. Processes and methods used for treatment and disposal c. Equipment to be used d. Any other information required e. Topographical information f. Geohydrological information g. Operational information	At discretion of Department
New Jersey	1. Disposal facility plans must comply with State solid waste management plan. 2. Registration statement on approved department forms must be submitted (registration=permit). 3. Engineering design must be submitted for approval. 4. Other information, as required, must be submitted, including: a. Topographic information b. Geohydrologic information	1 year

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TABLE 6 (continued).

State	Requirements	Duration of permit
New York	1. Permit application must include: a. Topographic and geohydrologic information b. Operational plan c. Contingency plan incase of emergency d. Engineering plan prepared by N.Y. registered firm e. Background sound data f. Detailed closure plan	At discretion of Department
North Carolina	1. Detailed site information must be submitted and approved. 2. Detailed operational information must be approved. 3. Approval letter of local government must be submitted. 4. Plans for design, construction and operation must be prepared by a professional engineer.	At discretion of Department
Oregon	1. Description of existing and proposed operation must be given. 2. Description of existing and proposed facilities must be given. 3. Recommendation of local governmental unit concerning solid waste disposal facility must be provided. 4. Any other information required by Department must be provided. 5. Detailed feasibility study and plans designed by professional engineer must be submitted.	10 years
Puerto Rico	1. Requirements are to be developed by the Board of Environmental Quality.	At discretion of Board
Rhode Island	1. Detailed topographic and geohydrologic information is required. 2. Detailed design specifications are required. 3. Detailed operational plan is required. 4. Detailed pollution control plans are required.	1 year
South Carolina	1. Sanitary landfill plans and engineering report, prepared by South Carolina registered engineer, must be submitted, including: a. Topographic information b. Geohydrologic information c. Projected use and refuse d. Operational plan e. Pollution protection plan	At discretion of Department
Texas	Design 1. Application information shall be prepared by a registered professional engineer for disposal sites servicing more than 5,000 people. 2. Application must include information that allows evaluation to insure protection of health, welfare, physical property of the people, and the environment, including: a. Topographic information b. Geohydrologic information c. Projected use and refuse d. Operational plan e. Pollution protection plan 3. Certification of approval by local government required.	For life of site or at discretion of Department
Virginia	1. Application must be made on approved form. 2. Information required as necessary to determine if the operation is safe and sanitary.	At discretion of Department
Washington	1. Detailed topographic and geohydrologic information is required. 2. Detailed design specifications are required. 3. Detailed operational plan is required. 4. Detailed pollution control plans are required. 5. Health Department must certify that all zoning, building, and other requirements are met.	1 year or at discretion of Health Department

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TABLE 7. ENFORCEMENT MEASURES AND PENALTIES FOR VIOLATIONS OF LAW RELATING TO MUNICIPAL SOLID WASTE DISPOSAL IN A SALINE ENVIRONMENT

ALABAMA SOLID WASTES DISPOSAL ACT
ALABAMA SOLID WASTES MANAGEMENT REGULATIONS
ALABAMA STANDARDS FOR DISPOSAL OF SOLID WASTES

Enforcement

1. Supervision of Department of Public Health (State and county). required
2. "Approval" (permit) can be cancelled

Penalties

1. Criminal
   a. misdemeanor: \$5-\$100/day of violation
   b. also, as provided in Title 22, Section 103, Code of Alabama, 1940, recompiled 1958

ALABAMA WATER POLLUTION CONTROL ACT
ALABAMA WASTE DISCHARGE PERMIT POLICIES AND PROCEDURES

Enforcement

1. Records, reports, monitoring as required by Commission
2. Investigation by Commission allowed
3. Permit can be suspended, modified, or revoked
4. Injunction or court order may be brought

Penalties

1. Civil
   a. liable for cost of restoration
   b. \$100-\$10,000/day of violation
2. Criminal(willful or gross negligence)
   a. first offense: \$2,500-\$25,000 and/or ≤1 yr in prison/day of violation
   b. second offense: ≤\$50,000 and/or ≤2 yr in prison/day of violation
3. Criminal(false statements or monitoring)
   a. ≤ \$10,000 and/or ≤6 months in prison/day of violation

ALASKA SOLID WASTE MANAGEMENT REGULATIONS

Enforcement

1. Records, reports, monitoring as specified in permit
2. Inspection and investigation allowed
3. Abatement order may be issued by Department
4. Permit can be revoked or suspended
5. Final inspection is required before closing

Penalties

1. Criminal(violation of provisions of chapter)
   a. misdemeanor: costs of violation ≤ \$25,000

(continued)

2. Criminal(willful violation of provisions of chapter)
    a. misdemeanor: ≤$25,000, costs of prosecution, and/or ≤1 year in prison/day of violation
3. Criminal(false information)
    a. misdemeanor: ≤$25,000 and/or 1 year in prison/violation

ALASKA WASTEWATER DISPOSAL REGULATIONS

Enforcement

1. Records, reports and monitoring as specified
2. Inspection and investigation allowed
3. Department may issue abatement order
4. Permit can be revoked or suspended

Penalties

1. Criminal(violation of provisions of chapter)
    a. misdemeanor: ≤$25,000 and costs of prosecution/day of violation
2. Criminal(willful violation of provisions of chapter)
    a. misdemeanor: ≤ $25,000, costs of prosecution, and/or ≤ 1 year in prison/day of violation
3. Criminal(false information)
    a. misdemeanor: ≤$25,000 and/or ≤ 1 year in prison/violation

CALIFORNIA SOLID WASTE MANAGEMENT AND RESOURCE RECOVERY ACT OF 1972

Enforcement

1. Sites must maintain records of disposal
2. Enforcement agency may modify, suspend, or revoke permit
3. Inspections and investigations allowed
4. Cease and desist order may be issued
5. Final report is due upon closing, detailing methods of water pollution prevention
6. Owner has continuing responsibility to protect waters from pollution

Penalties

1. Civil a. liable for cost of remedial work
2. Civil(intentional or negligent violation of permit)
    a. ≤ $1,000/day of violation

CALIFORNIA WATER POLLUTION CONTROL LAWS
CALIFORNIA WATER REGULATIONS

Enforcement

1. Investigations and inspections allowed
2. Monitoring may be required
3. Board may issue clean-up
4. Board may issue cease and desist order
5. Attorney General may petition for temporary restraining order, temporary injunction, or permanent injunction

Penalties

1. Civil a. liable for cost of remedial work
    b. ≤ $10,000/day of violation

(continued)

2. Criminal(discharge of waste, tampering with or refusing monitoring)
    a. \$2,500.00-\$25,000.00 and/or $\leq$ 1 year in prison/day of violation
    b. Second offense: $\leq$ \$50,000 and/or $\leq$ 2 years in prison/day of violation
3. Criminal(false statements)
    a. $\leq$\$10,000 and/or $\leq$ 6 months in prison

CALIFORNIA COASTAL ACT

Enforcement

1. Enforcement measures may be developed as necessary by local government

Penalties

1. Civil(violation of any provision)
    a. $\leq$ \$10,000
    b. additional fines of \$50.00-\$500.00/day of violation

CONNECTICUT SOLID WASTE MANAGEMENT ACT
CONNECTICUT SOLID WASTE MANAGEMENT REGULATIONS

Enforcement

1. Daily log of operations at landfill sties required
2. Inspections and investigations allowed
3. Monitoring may be required
4. Permit can be modified, suspended, or revoked

Penalties

1. Violator can be held in contempt of court for violation of court order

CONNECTICUT CLEAN WATER ACT

Enforcement

1. Records to be kept as required
2. Inspections and investigations allowed
3. Access to records by Commissioner allowed
4. Abatement order or orders to correct potential sources of pollution may be issued by Commissioner

Penalties

1. Civil(violation of provisions of chapter)
    a. liable for cost of restoration
    b. $\leq$ \$10,000/day of violation
2. Civil(willful or negligent violation of provisions)
    a. $\leq$ \$25,000 and/or $\leq$ 1 year in prison/day of violation
3. Criminal(willful or negligent violation of provisions)
    a. $\leq$ \$25,000 and/or $\leq$1 year in prison/day of violation
4. Criminal(false statements)
    a. $\leq$ \$10,000 and/or $\leq$6 months in prison

(continued)

CONNECTICUT TIDAL WETLANDS ACT

Enforcement

1. Investigations and inspections allowed
2. Permit can be modified, suspended, or revoked

Penalties

1. Civil(violations of any provisions)
    a. liable for cost of restoration
    b. ≤$1,000.00/day of violation

DELAWARE SOLID WASTE AUTHORITY ACT
DELAWARE SOLID WASTE DISPOSAL REGULATIONS

Enforcement

1. Investigations and inspections are allowed
2. Monitoring must be provided as required
3. Reports and records must be provided as required
4. Permit can be revoked, suspended or modified
5. Authority may seek temporary restraining order, preliminary or permanent injunction
6. Responsibility remains with landfill owner for 2 years following closure

Penalties

1. Civil
    a. $100.00-$1,000.00/day of violation

DELAWARE WATER POLLUTION CONTROL REGULATIONS

Enforcement

1. Records of monitoring must be available
2. Secretary may seek temporary order, temporary or permanent injunction from the Court of Chancery
3. Secretary may issue cease and desist order

Penalties

1. Civil
    a. $1,000.00-$100,000.00/day of violation
2. Criminal(violation of provisions of chapter
    a. $50.00-$500.00/day of violation
3. Criminal(false statements)
    a. $500.00-$5,000.00 and/or ≤ 6 months in prison

DELAWARE COASTAL ZONE ACT

Enforcement

1. Attorney General may issue cease and desist order
2. Court of Chancery may enjoin violations

Penalties

1. Civil
    a. ≤ $50,000/day of violation

DELAWARE WETLANDS ACT

Enforcement

1. Department may investigate activity in wetlands
2. Surety bond may be required by Department for wetland activity
3. Secretary may issue cease and desist order
4. Action for injunction may be brought by secretary

Penalties

1. Civil
    a. liable for cost of restoration
    b. $500.00-$10,000.00/day of violation

(continued)

FLORIDA RESOURCE RECOVERY AND MANAGEMENT ACT

Enforcement

1. Monitoring and analysis may be required
2. Inspections and evaluation allowed
3. Recording of closed disposal sites must be made in public record
4. Administrative order may be issued to abate control or prevent pollution
5. Department may seek injunctive action
6. Performance bond required
7. Responsibility remains with landfill owner for 2 years after closing

Penalties

1. Civil
    - a. liable for cost of restoration of damages to air, water or property
    - b. ≤$10,000.00/day of violation

FLORIDA AIR AND WATER POLLUTION CONTROL ACT
FLORIDA RULES ON POLLUTION OF WATERS

Enforcement

1. Monitoring as required
2. Reports on operations that may cause pollution are required
3. Inspections and investigations allowed
4. Permit can be modified, suspended, or revoked
5. Administrative order for corrective action may be issued
6. Action may be brought for a temporary or permanent injunction

Penalties

1. Civil
    - a. liable for costs of restoration
    - b. ≤$10,000.00/day of violation
2. Criminal(willful or negligent violation of provisions)
    - a. misdemeanor:$2,500.00-$10,000.00 and/or ≤6 months in prison/day of violation

FLORIDA BEACH AND SHORE PRESERVATION ACT

Enforcement

1. Department may issue order to move unsafe coastal construction

Penalties

1. Criminal(violation of provisions of chapter)
    - a. $500.00-$1,000.00/month of violation

FLORIDA ENVIRONMENTAL LAND AND WATER MANAGEMENT ACT OF 1972

Enforcement

1. Division of State planning, State's attorneys, all counties and municipalities may bring action to enjoin violations of provisions of chapter

Penalties

1. None given

GEORGIA SOLID WASTE MANAGEMENT ACT
GEORGIA SOLID WASTE MANAGEMENT RULES

Enforcement

1. Inspection and site investigation allowed by division

(continued)

2. Permit can be modified, suspended or revoked
3. Director may issue, modify or revoke orders to prohibit, control or abate improper solid waste handling
4. Emergency action orders may be issued by Director
5. Responsibility remains with landfill owner for 1 yr. after closure of site

Penalties

1. Civil(violation of provision or refusing to comply with order)
    a. ≤$1,000.00
    b. ≤$500.00/day of violation thereafter
2. Criminal(violation of any provision)
    a. misdemeanor/day of violation

GEORGIA WATER QUALITY CONTROL ACT

Enforcement

1. Inspections and investigations allowed
2. Monitoring, recording and reporting may be required
3. Permit can be modified, suspended or revoked
4. Director may issue, modify,or revoke orders to prohibit, control or abate polluion
5. Action may be taken to issue a temporary or permanent injunction

Penalties

1. Civil(violation of any provision)
    a. liable for cost of restoration
    b. ≤$10,000.00/day of violation
2. Criminal(violation of any provision)
    a. $2,500-$25,000 and/or ≤1 year in prison/day of violation
    b. after first offense: ≤$50,000 and/or ≤2 years in prison/day of violation
3. Criminal(false statements or tampering with monitoring)
    a. ≤$10,000 and/or ≤6 months in prison

GEORGIA COASTAL PROTECTION ACT

Enforcement

1. Inspections allowed
2. Suspend modify or revoke permit
3. Action may be taken to bring a temporary or permanent injunction
4. Cease and desist order can be issued

Penalties

1. Civil(violation of provisions or Departmental orders)
    a. ≤ $1,000/day of violation
    b. ≤ $500.00 for each addiional day of violation
2. Criminal(violation of provisions)
    a. misdemeanor

HAWAII ENVIRONMENTAL QUALITY LAW
HAWAII SOLID WASTE MANAGEMENT CONTROL REGULATIONS

Enforcement

1. Investigations allowed

(continued)

2. Monitoring may be required
3. Permit can be modified, suspended or revoked
4. Department may issue cease and desist orders
5. Action may be taken to issue a temporary or permanent injunction

Penalties

1. Civil and Criminal
    a. as provided in Chapter 342, Hawaii Revised Statutes

HAWAII WATER POLLUTION CONTROL REGULATIONS
HAWAII ENVIRONMENTAL QUALITY LAW

Enforcement

1. Investigations and inspections allowed
2. Records of monitoring must be maintained and kept for 3 yr
3. Complete, detailed plans and reports on existing or proposed areas may be required
4. Inspections of monitoring equipment or methods allowed
5. Sampling of discharge of pollution allowed
6. Permit can be modified, suspended or revoked

Penalties

1. Civil and Criminal
    a. as provided in Chapter 342, Hawaii Revised Statutes

LOUISIANA SOLID WASTE LAWS
LOUISIANA SOLID WASTE REGULATIONS

Enforcement

1. State Board of Health has power to enforce as necessary

Penalties

1. Civil (violation of provisions)
    a. first offense: ≤ $5,000.00
2. Criminal (violation of provisions)
    a. ≤ $50,000.00 and/or ≤ 60 days in prison/day of violation

LOUISIANA STREAM CONTROL COMMISSION ACT
LOUISIANA WATER QUALITY CRITERIA

Enforcement

1. Entry, inspections and investigations allowed
2. Temporary order may be issued in an emergency to stop pollution
3. Commission may bring any appropriate court action
4. Preliminary, temporary or permanent injunction may be brought

Penalties

1. Civil (pollution without permit, violation of permit, willful or negligent violation)
    a. liable for cost of restoration
2. Criminal (violation of provisions or any order)
    a. $100.00-$200.00 costs of prosecution and/or ≤ 1 year in prison/day of violation

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MAINE SOLID WASTE MANAGEMENT ACT
MAINE SOLID WASTE MANAGEMENT REGULATIONS

Enforcement

1. Municipality solid waste management reports required
2. Permit may be revoked
3. DEP inspection required before closing sanitary landfill site

Penalties

1. Civil(violation of provision)
    a. ≤ $500.00/day of violation

MAINE WATER POLLUTION CONTROL LAW
MAINE WATER QUALITY CONTROL REGULATIONS

Enforcement

1. Inspection testing and sampling by Department allowed
2. Records may be required
3. Attorney General may bring appropriate court action
4. Emergency injunction can be brought

Penalties

1. Article 3, Section 453(penalties), Section 454 (injunctions, civil and criminal actions) of the Maine Water Pollution Control Law repealed as of 2/16/79

MAINE COASTAL WETLANDS AND ZONING LAW

Enforcement

1. Attorney General may enjoin violations

Penalties

1. Civil(violation of provisions)
    a. liable for restoration costs
    b. ≤ $500.00/day of violation

MAINE LAND USE LAW

Enforcement

1. Investigations, inspection, testing, site evaluations allowed
2. Permit can be modified, suspended or revoked
3. Injunction or appropriate court action to prevent, restrain, correct or abate any violation

Penalties

1. Civil(violation of provision)
    a. ≤ $500.00/day of violation
2. Civil(false statements)
    a. ≤ $500.00/day of violation

MAINE SITE LOCATION ACT

Enforcement

1. Attorney General may enjoin any development begun without permit
2. Appropriate civil action taken by Attorney General to secure compliance with order of Board

Penalties

1. none given

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MARYLAND SOLID AND HAZARDOUS WASTE LAWS

Enforcement

1. Department allowed to conduct studies, surveys,and investigations
2. Records must be kept of disposal facilities
3. Bond required to insure proper closing of landfill site
4. Environmental Service may adopt rules necessary to enforce regulation of its projects concerning disposal

Penalties

1. Civil
   a. liable for costs of abating pollution
2. Criminal(violation of Environmental Service Act or any rules promulgated by Environmental Service
   a. misdemeanor: ≤ $1,000.00/day of violation

MARYLAND WATER POLLUTION CONTROL LAW

Enforcement

1. Investigations allowed
2. State Board of Health may order system or plant operating results to be improved
3. Records must be kept
4. Permit can be modified, suspended or revoked

Penalties

1. Civil(failure to comply with Board order
   a. $10.00-$500.00/day of violation
   b. $5.00-$50.00 for each additional day of violation

MARYLAND WATER RESOURCES LAW(Section 8-1413)

Enforcement

1. Investigations and inspections allowed
2. Report records may be required
3. Monitoring may be required
4. Permit maybe revoked.
5. Administration may issue order to correct violation
6. Attorney General may bring injunctive action

Penalties

1. Civil(violation of provisions, rules or orders)
   a. $500.00-$10,000.00/day of violation
   b. liable for cost of damages
2. Criminal(violation of provisions, rules or orders)
   a. first offense: ≤ $25,000 and/or ≤ 1 year in prison/day of violation
   b. second offense: ≤ $50,000.00 and/or ≤ 2 years in prison/day of violation
3. Criminal(false statements and monitoring)
   a. ≤$10,000.00 and/or ≤ 6 months in prison

MASSACHUSETTS SOLID WASTE LAW
MASSACHUSETTS SANITARY LAND FILL REGULATIONS

Enforcement

1. Permit can be suspended, modified or revoked

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2. Department may inspect landfill site to determine compliance with approved plans
3. Daily log of operational information required
4. Inspections and evaluation by Department allowed
5. Performance bond required
6. Responsibility for closing up to 1 year after

Penalties

1. Civil
    a. \$100.00-\$500.00/day of violation

MASSACHUSETTS CLEAN WATER ACT

Enforcement

1. Inspection and investigations allowed
2. Monitoring and record keeping must be provided as required
3. Permit can be modified, suspended or revoked
4. Cease and desist order may be issued
5. Attorney General may enjoin violation

Penalties

1. Civil(violation of provision, false representation)
    a. $\leq$ \$10,000/day of violation
2. Criminal(violation of provision, false representation)
    a. \$2,500.00-\$25,000.00 and/or $\leq$ 1 year in prison/day of violation

MASSACHUSETTS WETLAND PROTECTION LAW

Enforcement

1. Commissioner or agents may enter lands in question to undertake duties
2. Court may restrain violation

Penalties

1. Criminal(violation of order of Commissioner)
    a. \$10.00-\$50.00 and/or $\leq$ 1 month in prison
2. Criminal(violation of provision of chapter)
    a. $\leq$ \$10,000 and/or $\leq$ 6 months in prison/day of violation

MISSISSIPPI SOLID WASTE LAW
MISSISSIPPI SANITARY LANDFILL REGULATIONS

Enforcement

1. Permit can be revoked
2. Performance bond required
3. Inspections and investigations allowed
4. Civil action may be brought to recover fees and charges
5. Department may supervise as necessary to enforce
6. Records of closed landfills must be maintained in Public Deeds Office

Penalties

1. Criminal(violation of provision of chapter)
    a. misdemeanor: \$50.00-\$500.00/day of violation

MISSISSIPPI AIR AND WATER POLLUTION CONTROL ACT

Enforcement

(continued)

1. Monitoring must be provided as required
2. Records must be kept as required
3. Investigation and inspections by commission allowed
4. Permit can be modified, suspended or revoked

Penalties

1. Civil(violation of provisions of chapter)
    a. liable for cost of clean up
    b. liable for cost of restoration of fish and wildlife
    c. $50.00-$5,000.00/day of violation
2. Criminal(violation of provision of chapter)
    a. $2,500.00-$10,000.00/day of violation

MISSISSIPPI COASTAL WETLANDS PROTECTION LAW

Enforcement

1. Investigations allowed
2. Performance bond may be required
3. Permit can be suspended or revoked
4. Action may be brought for injunctive relief

Penalties

1. Civil
    a. liable for the cost of restoration
    b. ≤ $500.00/day of violation
2. Criminal(violations of provisions)
    a. misdemeanor: $100.00-$1,000.00 and/or ≤ 30 days in prison/day of violation
3. Criminal(disturbing scientific instruments)
    a. ≤ $500.00 and/or ≤ 30 days in prison

NEW HAMPSHIRE WASTE DISPOSAL LAW

Enforcement

1. Inspections allowed
2. Division of Public Health may close disposal area
3. Superior Court may restrain or enjoin the operation of a private disposal site, or the disposal of out-of-State waste
4. Permit can be suspended or revoked
5. Owner is responsible for landfill for 1 year following closing
6. Daily operational log required

Penalties

1. Civil(disposing of waste on private site)
    a. $100.00/violation
2. Civil(disposing of out-of-State waste)
    a. $200.00-$2,000.00/violation
3. Civil(throwing, depositing, dumping of refuse)
    a. $25.00-$100.00/violation
4. Criminal(disposal of putrescible waste or human excrement without permit)
    a. ≤ $100.00 and/or ≤ 60 days in prison/violation

NEW HAMPSHIRE WATER POLLUTION CONTROL LAW

Enforcement

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1. Inspections and investigations allowed
2. Monitoring and reporting as required
3. Access to records by Commission allowed
4. Cease and desist order may be issued

Penalties

1. Civil(violations or provisions of permit or order)
    - a. ≤ $10,000/day of violation
2. Criminal(willful or negligent violation of provisions, permit or order; false statements or monitoring results)
    - a. ≤ $25,000 and/or ≤ 6 months in prison/day of violation

NEW JERSEY SOLID WASTE LAWS
NEW JERSEY WASTE CONTROL ACT
NEW JERSEY SOLID WASTE MANAGEMENT REGULATIONS

Enforcement

1. Monitoring as required
2. Daily records of waste disposal must be kept
3. Registration can be suspended or revoked
4. Action for temporary or permanent injunction may be taken
5. Orders to correct violation may be issued by Commissioner
6. Landfill must be recorded in Public Deeds Office
7. Responsibility for landfill remains with owner after closing for a time specified by Commissioner

Penalties

1. Civil(violation of provisions)
    - a. ≤ $3,000.00/day of violation
2. Criminal(knowing violation of provision)
    - a. misdemeanor
      individual: ≤ $50,000.00 and/or ≤ 3 years in prison/day of violation
      corporation: ≤ $100,000.00/day of violation
3. Criminal(violation of provision)
    - a. first offense:≤ $500.00
    - b. second offense: $100.00-$1,000.00
    - c. third offense: $500.00-$1,000.00

NEW JERSEY WATER POLLUTION CONTROL ACT
NEW JERSEY WATER POLLUTION CONTROL REGULATIONS

Enforcement

1. Inspections and investigations allowed
2. Monitoring as required
3. Permit can be suspended, modified or revoked
4. Order to comply may be issued by Commission
5. A temporary or permanent injunction may be brought

Penalties

1. Civil
    - a. liable for costs of monitoring and inspection required for enforcement
    - b. liable for cost of restoration
    - c. liable for cost of clean up

(continued)

2. Administrative
    a. ≤ $5,000.00/day of violation
3. Court
    a. ≤ $10,000.00/day of violation
4. Civil(violation of provisions)
    a. ≤$3,000.00/day of violation
5. Criminal(willful and negligent violation of provision)
    a. first offense: $2,500.00-$25,000.00 and/or 1 year in prison/day of violation
    b. second offense: $5,000.00-$50,000.00 and/or ≤ 2 years in prison/day of violation
6. Criminal(false statements or monitoring)
    a. ≤ $10,000.00 and/or ≤ 6 months in prison

NEW JERSEY COASTAL AREA FACILITY REVIEW ACT

Enforcement

1. Permit can be modified, suspended or revoked
2. Civil action may be taken to bring an injunction

Penalties

1. Civil(violation of provisions)
    a. ≤$3,000.00/day of violation

NEW JERSEY WETLANDS LAW

Enforcement

1. Superior Court may restrain violations of orders

Penalties

1. Civil(violations of provisions)
    a. liable for cost of restoration
    b. ≤ $100.00/violation

NEW YORK SOLID WASTE MANAGEMENT RULES
NEW YORK ENVIRONMENTAL CONSERVATION LAW (Article 27)

Enforcement

1. Inspections and investigations allowed
2. Sampling, monitoring and reporting as required
3. Permit can be modified, suspended or revoked
4. Detailed plan and surety bond required for closure
5. Closure responsibility remains for 5 years
6. Landfill site must be shown on property deed
7. Groundwater monitoring and gas venting facilities must be maintained for 5 years after closing

Penalties

1. Civil(violation of private waste disposal section, Article 27, Title 3)
    a. ≤ $500.00/day of violation
2. Civil(violation of N.Y. Solid Waste Facilities Rules)
    a. asset forth in N.Y. Environmental Conservation Law, Section 27-0509
3. Criminal(violation of private waste disposal section, Article 27, Title 3)
    a. ≤ $1,000.00/day of violation

(continued)

4. Criminal(violation of N.Y. Solid Waste Facilities Rules)
    a. as set forth in N.Y. Environmental Conservation Law, Section 27-0509

NEW YORK WATER POLLUTION CONTROL LAW (Article 17-ECL)

Enforcement

1. Inspection, investigations and site visits allowed
2. Monitoring must be provided as required
3. Record keeping must be provided as required
4. Reporting required once/month or as specified
5. Permit can be modified, suspended or revoked
6. Department has powers of search and arrest

Penalties

1. Civil
    a. ≤ $1,000.00/day of violation
2. Criminal
    a. ≤ $50.00-$1,000.00 and/or ≤ 1 year in prison/day of violation

NEW YORK WETLANDS LAW

Enforcement

1. Inspections allowed
2. Bond posted to insure compliance with permit
3. Permit can be suspended or revoked
4. Cease and desist order

Penalties

1. Civil
    a. liable for cost of restoration of wetland
    b. ≤ $3,000.00/day of violation
2. Criminal
    a. first offense: $500.00-$1,000.00/day of violation
    b. second offense: misdemeanor - $1,000.00-$2,000.00 and/or 15 days-6 months in prison and/or restoration of wetland

NORTH CAROLINA SOLID WASTE DISPOSAL LAW
NORTH CAROLINA SOLID WASTE DISPOSAL REGULATIONS

Enforcement

1. Investigations during and after operation allowed
2. Injunctive action may be taken
3. Permits must be registered in County Deeds Office

Penalties

1. Criminal(violation of provision or rules)
    a. ≤ $50.00 and/or ≤ 30 days in prison/day of violation

NORTH CAROLINA WASTEWATER DISCHARGE PERMIT REGULATIONS

Enforcement

1. Inspections and investigations allowed
2. Monitoring as required and monthly monitoring reports
3. Reporting and record keeping as required
4. Permit can be modified, suspended or revoked

(continued)

Penalties
1. Criminal
   a. as provided for in NCGS 143-215.69
   b. \$100.00-\$1,000.00/day of violation

OREGON SOLID WASTE CONTROL LAW
OREGON SOLID WASTE CONTROL REGULATIONS

Enforcement
1. Inspections and investigations allowed
2. Monitoring as required
3. Reporting as required
4. Permit can be suspended or revoked
5. Temporary or permanent injunction may be brought against violators
6. No grants or funds to municipalities who operate landfill without permit

Penalties
1. Civil(violation of provisions, rules, orders)
   a. $\leq$ \$500.00/day of violation
2. Criminal(violation of provisions, rules, orders)
   a. Class A misdemeanor: $\leq$ \$3,000.00 and/or $\leq$1 year in prison/day of violation

OREGON WATER POLLUTION CONTROL LAWS
OREGON WATER QUALITY CONTROL REGULATIONS

Enforcement
1. Commission may perform or cause to be performed all acts necessary to implement the FWPCA (1972)
2. Revoke permit

Penalties
1. Civil
   a. liable for cost of restoration of fish and wildlife
   b. \$50.00-\$10,000.00/day of violation
2. Criminal(violation of provisions or rules)
   a. Class A misdemeanor: $\leq$ \$25,000.00 and/or $\leq$ 1 year in prison/day of violation

OREGON LAND USE LAW

Enforcement
1. Investigations allowed
2. Action may be brought for injunction

Penalties
1. Civil
   a. civil action may be brought as necessary

PUERTO RICO PUBLIC POLICY ENVIRONMENTAL ACT (SOLID WASTE)

Enforcement
1. Investigations of solid waste disposal sites allowed

Penalties
1. Civil
   a. liable for costs of investigation and monitoring to determine violation
   b. liable for cost of clean-up
   c. liable for cost of restoring environment

(continued)

2. Administrative
    - a. ≤ $25,000.00/day of violation
    - b. contempt or recurrence - ≤ $50,000.00/day of violation

3. Criminal(violation provisions)
    - a. misdemeanor: $200.00-$500.00/day of violation
    - b. $500.00 for each additional day of violation

4. Criminal(false statements)
    - a. $100.00-$500.00

PUERTO RICO WATER POLLUTION CONTROL LAW

Enforcement

1. Inspection and analyses allowed
2. Injunction may be brought against violations
3. Orders may be issued to abate pollution

Penalties

1. Civil
    - a. liable for costs of investigation and monitoring to determine violation
    - b. liable for cost of clean-up
    - c. liable for cost of restoring environment
2. Administrative
    - a. ≤ $25,000/day of violation
    - b. contempt or recurrence - ≤ $50,000.00/day of violation
3. Criminal(violation of provisions)
    - a. $100.00-$1,000.00 and/or ≤ 90 days in prison/day of violation
4. Criminal(false statements)
    - a. $100.00-$500.00

RHODE ISLAND SOLID WASTE LAW
RHODE ISLAND SOLID WASTE MANAGEMENT REGULATIONS

Enforcement

1. Inspections and investigations allowed
2. Monitoring and reporting must be provided as required
3. Examination of records allowed
4. Suspend or revoke license
5. Certificate of closure from department required

Penalties

1. Civil(disposing of out-of-state waste)
    - a. ≤ $500.00
2. Criminal(operating a solid waste refuse facility without a license)
    - a. ≤ $500.00 and/or ≤ 30 days in prison/day of violation

RHODE ISLAND WATER POLLUTION CONTROL LAW

Enforcement

1. Inspection and investigations allowed
2. Director may order violator to use a particular system
3. Permit can be modified, suspended or revoked

Penalties

1. Criminal(violation of provisions or orders)
    - a. ≤ $500.00 and/or ≤ 30 days in prison/day of violation

(continued)

2. Criminal (not allowing director or his agent to fulfill duties)
    a. misdemeanor: ≤ $500.00

RHODE ISLAND COASTAL MANAGEMENT COUNCIL ACT

Enforcement
1. Investigations and entrance on private land allowed
2. Cease and desist orders may be issued by council
3. Council may order violator to remedy violation

Penalties
1. Criminal(violation of council order)
    a. misdemeanor: ≤ $300.00 and/or ≤ 3 months in prison/day of violation

SOUTH CAROLINA LANDFILL REGULATIONS
SOUTH CAROLINA INDUSTRIAL SOLID WASTE DISPOSAL SITE REGULATION

Enforcement
1. Routine inspection investigation and evaluation of landfill site allowed.
2. Monitoring and records as required
3. Cease and desist order may be issued
4. Permits may be suspended or revoked
5. Final inspection required and responsibility for restoration held by owner during sufficient time period to assure recovery of land

Penalties
1. Civil
    a. liable for costs of restoring fish and other wildlife
2. Criminal(violation of provisions, rules, or orders concerning landfill operation)
    a. misdemeanor: ≤ $100.00 and/or ≤ 30 days in prison/day of violation
3. Criminal(violation of industrial solid waste disposal site regulation)
    a. misdemeanor: $100.00-$500.00 and/or 2 years in prison/day of violation

SOUTH CAROLINA POLLUTION CONTROL ACTS

Enforcement
1. Inspection and investigations allowed
2. Monitoring and records must be provided as required
3. Cease and desist order may be issued
4. Suspend or revoke permit

Penalties
1. Civil
    a. liable for cost of restoring fish and other wildlife
2. Civil(violation of provisions rules, permits, orders; False statements or monitoring)
    a. ≤ $10,000/day of violation
3. Criminal(willful and negligent violation of provisions, rules, permits and orders; false statements or monitoring)
    a. misdemeanor: $500.00-$25,000.00 and/or ≤ 2 years in prison/day of violation

(continued)

TEXAS SOLID WASTE DISPOSAL ACT
TEXAS SOLID WASTE DISPOSAL REGULATIONS

Enforcement

1. Inspection and investigation allowed
2. Local enforcement agency may close site
3. Permit may be modified, suspended, or revoked
4. Injunctive action maybe brought
5. Bond required for satisfactory closing
6. Affidavit to the public must remain on file in Deeds Office

Penalties

1. Civil(violation of provision)
    a. $50.00-$1,000.00/day of violation

TEXAS WATER QUALITY ACT
TEXAS WATER QUALITY RULES

Enforcement

1. Inspection and investigation allowed
2. Monitoring and reporting as required
3. Examination of records allowed
4. Action may be brought for injunctive relief
5. Permit may be modified, suspended or revoked

Penalties

1. Civil(violation of provisions, permits, and orders)
    a. $50.00-$1,000.00/day of violation
2. Criminal(violation of provisions, permits, orders)
    a. $10.00-$1,000.00/day of violation

VIRGINIA SOLID WASTE DISPOSAL LAW
VIRGINIA SOLID WASTE REGULATIONS

Enforcement

1. Inspections allowed
2. Permit may be revoked

Penalties

1. none given

VIRGINIA STATE WATER CONTROL LAW

Enforcement

1. Investigations and inspections allowed
2. Monitoring as required
3. Records and reports as required
4. Permit may be modified or revoked
5. Cease and desist order may be issued
6. Action may be brought for injunctive relief

Penalties

1. Civil
    a. liable for cost of investigation of environmental problems and for costs of restoration
2. Civil(violation of statewide control law, rules, orders permits)
    a. $\leq$ $10,000/day of violation
3. Civil(false statements or monitoring
    a. $100.00-$25,000/violation

(continued)

4. Civil(violation of Groundwater Act of 1973)
    - a. $10.00-$250.00/violation

WASHINGTON SOLID WASTE MANAGEMENT LAW

Enforcement

1. Investigations and inspection allowed
2. Permit may be suspended
3. Jurisdictional Health Department may make rules necessary to enforce solid waste law

Penalties

1. Criminal(disposal of solid waste without permit)
    - a. misdemeanor

WASHINGTON WATER POLLUTION CONTROL LAWS

Enforcement

1. Inspection and investigation allowed
2. Monitoring must be provided as required
3. Reporting must be provided as required
4. Permit may be suspended, modified or revoked
5. Action may be brought for injunctive relief

Penalties

1. Civil
    - a. liable for cost of restoration of environment
    - b. liable for cost of restocking wildlife
    - c. ≤ $5,000/day of violation
2. Criminal
    - a. ≤ $10,000 and/or ≤ 1 year in prison/day of violation

WASHINGTON SHORELINE MANAGEMENT ACT

Enforcement

1. Modify or revoke permit
2. Action may be brought for injunctive relief
3. Cease and desist order may be issued
4. Responsibility rests with landfill owner for 5 years after closing
5. A disposal site statement must be on record at the County Auditors Office

Penalties

1. Civil
    - a. liable for cost of restoration and cost of court
2. Criminal(willful activity on shorelines in violation of provisions or rules)
    - a. misdemeanor: $25-$1,000 and/or ≤ 90 days in prison/violation
    - b. third offense: $500-$1,000/violation

TABLE 8. STATE-BY-STATE COMPARISON OF MAJOR LAWS AND PENALTIES REGARDING MSW DISPOSAL IN A SALINE ENVIRONMENT

State	Solid waste laws		Water pollution laws		Coastal wetland laws		Coastal zone laws	
	Civil	Criminal	Civil	Criminal	Civil	Criminal	Civil	Criminal
Alabama	X	X	X	X				
Alaska		X		X				
California	X		X	X			X	
Connecticut	X(*)		X	X	X		X	
Delaware	X	X	X	X	X		X	
Florida	X		X	X				X
Georgia	X	X	X	X	X	X		X
Hawaii	X	X	X	X				
Louisiana	X	X	X	X				
Maine	X				X		X	
Maryland	X	X	X					
Massachusetts	X		X	X		X		
Mississippi		X	X	X	X	X		
New Hampshire	X	X	X	X				
New Jersey	X	X	X	X	X			
New York	X	X	X	X	X			
North Carolina		X		X				
Oregon	X	X	X	X				
Puerto Rico	X	X	X	X				
Rhode Island	X			X				
South Carolina	X	X	X	X				
Texas	X		X	X				
Virginia			X					
Washington	X	X	X	X			X	X

*Cease and desist orders can be enforced through court orders and subsequent contempt citations

TABLE 9. STATE CRITERIA AND PERFORMANCE STANDARDS FOR MSW DISPOSAL FACILITIES

State	Location	Design and operation	Performance
Alabama	1. Facility should be located so as not to cause water pollution (surface or ground) 2. Facility should be located where practical, convenient, and feasible 3. Sufficient land should be available for planned life of site 4. Sufficient cover should be available	1. Disposal shall be by one of three methods: a. sanitary landfill or landfill b. incinerator c. other sanitary methods as required 2. All-weather access road required 3. Facility should be designed to prevent water pollution 4. Cover must meet following criteria: a. waste in 2 ft layers, compacted as densely and quickly as possible b. 6 in. daily cover c. final cover $\leq$ 2 ft graded to prevent ponding and erosion 5. Lift $\leq$ 8 ft 6. Slope $\leq$20 -30 on sides	1. No open burning or dumping permitted 2. Litter and vectors must be controlled 3. Trucks should be covered 4. No radioactive waste permitted 5. No hazardous waste in same landfill
Alaska	1. Disposal is restricted in permafrost areas 2. Facility should be located so as not to cause water pollution 3. No disposal permitted in areas subject to surface water overflow 4. Facility should be located so as not to be a source of pollution	1. Cover must meet following criteria: a. 2 ft. layers of waste before compaction b. daily cover as permit requires c. final cover $\leq$2 ft graded and vegetated to prevent ponding and erosion 2. Lift $\leq$8 ft	1. No open burning or dumping permitted 2. Operation must be clean and neat 3. Erosion must be controlled 4. Water pollution must be controlled
California	1. Disposal permitted only at sites approved by regional water quality control board according to classifications of sites and wastes (Class II waste includes municipal solid waste) a. Class I Disposal Site - complete protection is provided for all time for ground and surface water b. Class II Disposal Site - protection is provided for ground and surface water from Class II waste 2. Disposal area shall not be subject to washout 3. Geologic conditions must be such that there is no vertical continuity between waste and surface and ground waters 4. Disposal sites shall not be over zones of faulting	1. Plan must include the following based on site-by-site and waste classifications a. control measures for waste, tributary surface drainage, subsurface drainage, rainfall infiltration, erosion control b. limited to area and depth of waste 2. Disposal areas should be protected from washout or floods	1. No open burning or dumping permitted 2. Litter, vectors and dust must be controlled 3. No water pollution may occur 4. Leachate and subsurface flow shall be contained within the site 5. Gases and leachate shall not affect groundwater 6. Erosion must be controlled

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TABLE 9 (continued).

State	Location	Design and operation	Performance
		and provided with adequate drainage system to minimize surface water run-off onto or into fill to prevent erosion of fill or collection of standing water	
Mississippi	1. Disposal site should not be in flood-plain without protection from 50-year flood 2. Minimum of 5 ft from groundwater level 3. Adequate cover material must be available 4. Site must be geographically and economically feasible	1. All-weather access road shall be provided 3. Access must be limited by fencing 4. Cover must meet following criteria: a. 2 ft layer of waste after compaction equipment b. daily cover = 6 in c. final cover = 2 ft placed within 1 week of areas completion, seeded and graded to prevent ponding 5. Final grade should be no more than 30° to prevent erosion 6. Lift ≤10 feet	1. Dust, odors, vectors and litter must be controlled 2. Leachate and gas problems must be controlled 3. Facility must operate economically clearly and and in a pollution free manner 4. Site must be made aesthetically pleasing after closing
New Hampshire	1. Site must be located so as not to cause traffic problems 2. Site must be located so as not to destroy or historical site 3. Adequate cover material must be available 4. No waste disposal permitted on banks of water 5. The nearness of private dwellings, highways, and the potential for air and water pollution and fire hazards will be taken into account when granting site approval 6. There must be a minimum of 6 ft to groundwater level 7. There must be a minimum of 6 ft to bedrock 8. No disposal permitted in areas subject to flooding 9. No disposal permitted on sloping area (>15%)	1. Access limited by fencing 2. Supervision during operating hours 3. Good access road required 4. Measures taken to control fire 5. Topography or plantings should provide natural screenings 6. Fill surface shall be graded and have a drainage system to prevent erosion and ponding 7. Cover must meet following criteria: a. daily cover - 6 in. easily graded and handled under freezing conditions b. intermediate cover - provides seal against percolation of water deposited within 1 month, graded at 2% c. final cover - 2 ft table to support vegetation, graded at 2% to prevent ponding and erosion	1. No open burning or dumping permitted 2. Vectors, litter and dust must be controlled 3. Erosion and ponding controlled 4. Site must be made aesthetically pleasing after closing 5. Water pollution must be controlled
New Jersey	1. No disposal permitted where waste will contact ground or surface water 2. No landfill sites may be located within a 2½-mile radius of an airport	1. Engineering design must be approved 2. Measures must be taken to prevent fire 3. Only one working face may be used at a time and it should be ≤150 ft wide 4. Exposed surface of waste must be 15,000 ft^2 and must not be exposed for more than 24 hours	1. No open dumping or burning permitted 2. Dust, litter, odors and vectors must be controlled 3. Hazardous wastes allowed only if approved and if leachate collection system is available 4. Erosion must be controlled 5. Gas and leachate must be controlled 6. No surface or groundwater pollution permitted

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TABLE 9 (continued).

State	Location	Design and operation	Performance
Connecticut	1. Minimum of 1000 ft between wastes and water supply wells 2. Minimum of 60 in. between waste and groundwater 3. No contact is permitted with surface water	1. Access must be prevented by fences 2. Measures must be taken to prevent fire 3. Provisions must be made for measuring type and volume of waste 4. Certified operator must be present 5. Facility must be protected from 50 year flood on floodplain 6. Cover must meet following criteria: a. 3 ft layers of waste b. Daily cover = 6 in c. Interim cover (if area is not to be used for 9 months) 1 ft with adequate vegetation d. Final cover ≤ 2 ft with vegetation graded at 2% to prevent ponding and erosion 7. Lift ≤10 ft	1. No open burning or dumping is permitted 2. Litter, vectors and dust must be controlled 3. Decomposition gases must be controlled 4. Erosion must be controlled 5. No sewage or hazardous waste is permitted
Delaware	1. Facility must be a minimum of 3 ft above groundwater 2. Facility must be a minimum of 100 ft from surface water	1. Access must be limited by fencing 2. Supervision required during operating hours 3. Provisions must be made for measuring type and volume of waste 4. Wells must be dug to determine water quality and flow 5. Impermeable liner required at all disposal sites (natural or manmade) 6. Practicable level of technology must be applied to leachate collection and treatment 7. Monitoring wells for water, gas, and leachate must be maintained and monitored for 5 years after closing 8. Cover must meet following criteria: a. 2 ft layers of waste after compaction b. Daily cover = 6 in c. Final cover ≤ 2 ft with vegetation and graded at 2% to prevent ponding and erosion 9. Lift ≤10 ft	1. No open burning is permitted 2. Litter, vectors, dust and odor must be controlled 3. Gases must be controlled at site -- no lateral migration is permitted 4. Erosion must be controlled 5. No sewage or hazardous waste may be accepted without special approval
Florida	1. Facility must be a minimum of 5 ft from normal groundwater level 2. Facility must be a minimum of 200 ft from body of water except with proper control measures 3. Disposal must not be located:	1. Access must be limited by fence 2. Provide continuous supervision 3. All weather road available 4. Measures must be taken to prevent fire 5. Methods must be developed for collection, control and treatment of surface runoff	1. No open burning permitted 2. Litter, dust vectors & odors, must be controlled 3. Full time supervision 4. Erosion must be controlled 5. No sewage or hazardous waste is permitted without special approval

(continued)

TABLE 9 (continued)

State	Location	Design and operation	Performance
	a. on watershed of any surface public water supply b. where leachate may cause pollution c. on a stream bank hydraulically connected to any aquifer d. in a sink hole, in limestone or gravel pit e. in area subject to frequent flooding unless drainage provisions approved f. adjacent to the cone of influence of a public water supply g. in an area open to public view without proper screening h. on a public highway, alley, or road i. within the boundaries of an airport j. within 2 miles of an airport 4. Facility must be a minimum of 200 ft from habitation with public water supply 5. Facility must be a minimum of 1000 ft from habitation with private water supply	6. Leachate must be collected and treated 7. Gas control system must be available if necessary 8. Cover must meet following criteria: a. 2 ft layer of waste compacted to 1 ft b. daily cover = 6 in c. intermediate cover = 1 ft within 7 days of area completion d. final cover = 2 ft with vegetation and graded to prevent ponding and erosion 9. Lift ≤ 10 ft 10. Side slopes are not to exceed 1 vertical/3 horizontal grade	
Georgia	1. Facility must be located so as not to impair quality of environment, ground, or or surface waters	1. Access to site must be limited 2. All-weather road is necessary 3. Supervision required during operating hours 4. Measures must be taken to prevent fire a. waste must be spread evenly and compacted as soon as possible b. daily cover = 6 in c. intermediate cover = 1 ft d. final cover = 2 ft , graded to prevent ponding and erosion 6. Sanitary landfill shall be operated to prevent air, water, and land pollution, public health hazards, and nuisances	1. No open burning or open dumping permitted 2. Litters, vectors, odors must be controlled 3. No scavenging permitted 4. Hazardous wastes may be accepted only as approved
Hawaii	1. There must be a minimum of 5 ft to groundwater level 2. Disposal of waste in areas subject to flooding or leachate pollution is permitted only under special conditions a. There must be a minimum of 5 ft to groundwater table b. Offsite drainage over landfill must be controlled c. Waste must be deposited to prevent waste leachate or eroded particles from entering water	1. Access to site must be limited 2. All-weather road necessary 3. Fire must be prevented 4. Waste must be deposited so as to prevent pollution 5. Cover: a. 2 ft layers of waste before compaction b. daily cover = 6 in c. intermediate cover = 1 ft d. final cover = 2 ft graded and vegetated to prevent ponding and erosion	1. Entranceway and roadway to working face must be kept clear 2. Insects, birds & rodents must be controlled 3. No scavenging permitted 4. Landfill must be conducted in safe and sanitary manner 5. Erosion should be controlled

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TABLE 9 (continued).

State	Location	Design and operation	Performance
Louisiana	1. Disposal shall not occur where drainage will pollute any well or drain into private property	1. Solid waste should be disposed of so as to prevent ground or surface water pollution 2. Provision should be made for prompt disposal	1. Vectors must be controlled 2. Nuisances must be controlled
Maine	1. Facility must be a minimum of 5 ft above groundwater level 2. Surficial soils underlying waste to depth of 5 ft shall be well-graded, granular, and contain 15%-40% fines 3. Site should be sloped less than 15% 4. There must be a minimum of 300 ft to a classified body of water 5. There must be a minimum of 1,000 ft to residence or potable water supply	1. Limited access and/or adequate policing required 2. Supervision required during operating hours 3. Measures taken to prevent fire 4. Cover: a. 2 ft layers of waste before compaction b. daily cover = 6 in c. intermediate cover = 1 in where not to be used within 14 days d. final cover = 2 ft seeded and graded, with a slope not to exceed 2:1 to prevent ponding and erosion (cover material shall have a minimum of 15% fines) 5. Side slopes graded so as not to exceed 3:1	1. No open burning permitted 2. Vectors, dust, odors, and litter must be controlled 3. Hazardous waste must be disposed under special circumstances 4. Disposal area should be well drained 5. Leachate and gas problems should be corrected 6. Erosion should be controlled
Maryland	1. Disposal site cannot be within city of Baltimore or within ½ mile of hospital	----	1. Facility should be closed and covered to prevent erosion, health and safety hazards, nuisances, and pollution
Massachusetts	1. Avoid disposal in wetlands and floodplains where possible 2. Minimum of 4 ft to maximum groundwater level 3. Adequate cover material must be available 4. Facility must be located where potential is minimal 5. Geological characteristics are such that water pollution or gas problems do not arise 6. There must be a minimum of 60 ft to surface water	1. Access must be limited by fencing 2. Access road must be available even in ordinary inclement weather 3. Measures shall be taken to prevent fire 4. Supervision is required during operating hours 5. Cover must meet the following criteria: a. waste-2 ft layers with at least 4 passes of compaction equipment b. daily cover - 6 ft of material, easily graded and handled in freezing conditions c. intermediate cover - 1 ft to provide seal against water percolation, graded at 2% angle, deposited after 1 month d. final cover - 2 ft at a 2% grade able to support vegetation 6. Side slope graded ≤ 30% from horizontal 7. Fill surface and site shall be graded	1. No open burning permitted 2. Dust, vectors, litter and odors must be controlled 4. Must maintain landfill site for 1 yr after closing 5. Completed landfill must not interfere with proper drainage of adjacent areas 6. Erosion must be controlled 7. Decomposition gases must be controlled 8. Leachate must be controlled

(continued)

FIGURE 9 (continued).

State	Location	Design and operation	Performance
		5. Side slopes and working face must be graded to prevent ponding (2 horizontal: 1 vertical) 6. Gas venting and monitoring systems required 7. Groundwater monitoring system required 8. Cover must meet following criteria: a. layers of waste compacted to density of 700 lb/yd^3 yard b. daily cover = 6 in c. intermediate cover deposited every 6 months d. final cover - 2 ft graded and planted to prevent erosion and pending	
New York	1. Permit required for wetland disposal 2. Sites in ground or surface water not permitted 3. Sites on Class I or II Agricultural land not permitted 4. Sites on floodplains must be floodproofed 5. Minimum 5 ft between solid waste and groundwater level or bedrock 6. Disposal shall take into account horizontal movement of water	1. Access must be limited by fences 2. All-weather access road required 3. Supervision during operating hours 4. All fill areas or excavations must be 50 ft from boundary 5. Specific sound level requirements must be met 6. At least 3 groundwater monitoring wells must be located at new facilities 7. Leachate control structures or systems may be required 8. Cover must meet following criteria: a. 2 ft layer of waste before compaction b. daily cover required c. intermediate cover required when area not to be used within 30 days d. final cover - graded, planted and having proper drainage control structures to prevent ponding and erosion 9. Lift $\leq$10 ft	1. No burning permitted without special permit 2. Litter, vectors, dust and odors must be controlled 3. Gases must be controlled 4. Ponding and erosion must be prevented 5. No leachate shall drain or discharge into surface waters except pursuant to SPDES permit 6. Hazardous wastes accepted only if special approval is granted 7. Landfill owner maintains responsibility for 5 years
North Carolina	1. Site plans approved only for those areas where landfill rules can be maintained (Special concern areas are those with high water tables, floodplains special stream and resevoir classifications) 2. No disposal permitted in water	1. Access must be limited by fences 2. Supervision during operating hours 3. All-weather access road 4. Surface water should be diverted from operational area 5. Cover must meet following criteria: a. daily cover = 6 in. b. final cover = 2 ft of top soil.	1. No open burning permitted 2. Litter, odors, vectors, dust controlled 3. Erosion and ponding controlled 4. No hazardous wastes allowed without a special permit 5. Disposal facility must operate so as not to be a health hazard

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TABLE 9 (continued).

State	Location	Design and operation	Performance
		graded and with vegetation to prevent ponding and erosion 6. Solid waste disposal should be restricted to smallest possible area and compacted as densely as possible	
Oregon	1. Detailed description of location required 2. Safe distance must be maintained between groundwater level and solid waste 3. No disposal permitted in areas subject to flooding without proper protection	1. Access must be limited by fences 2. Supervision required during operating hours 3. Access roads must be all-weather 4. Fires must be controlled 5. Site shall be screened to prevent public view 6. Area of exposed waste must be kept as small as possible 7. Groundwater monitoring wells must be installed as required 8. Control and/or treatment of leachate must be provided as required 9. Cover must meet the following: criteria: a. waste spread in 2 ft layers and graded (3 horizontal:1 vertical) b. daily cover = 6 in c. final cover = 1 in. graded and seeded to prevent ponding and erosion 10.Lift as specified in approved operating plan	1. No open dumping 2. No open burning; burning at distances greater than 500 ft allowed with proper permits 3. Dust, litter, odors and vectors controlled 4. Erosion controlled 5. Leachate production should be minimized 6. Surface contours shall be maintained to prevent surface run-off from flowing into fill 7. Environment must be protected and conserved
Puerto Rico	To be developed by the Board of Environmental Quality	To be developed by the Board of Environmental Quality	To be developed by the Board of Environmental Quality
Rhode Island	1. Refuse must be placed a minimum of: a. 4 ft to groundwater b. 200 ft to surface or drinking water	1. Access limited by fences 2. Fires must be controlled 3. Supervision during operating hours 4. 4-day supply of cover material 5. Impermeable liner if necessary to prevent leachate movement 6. Working face $\leq$ 150 ft 7. Cover must meet following criteria: a. daily cover = 6 in b. intermediate cover = 6 in c. final cover = 24 in , graded and seeded to prevent erosion and ponding 8. Lift $\leq$ 12 ft	1. No open dumping or burning permitted 2. Control of vectors, dust and litter required 3. Gas movement should be controlled 4. Water pollution from leachate not permitted 5. Erosion and ponding controlled 6. Special permit required for hazardous or special waste disposal
South Carolina	1. Facility location must prevent water pollution 2. Adequate cover material available	1. Access must be limited by fences 2. Supervision during operation required. 3. All weather access road required	1. Disposal operation should be clean and neat 2. No open burning or dumping permitted 3. Vectors, litter, dust and odors to be controlled

(continued)

TABLE 9 (continued).

State	Location	Design and operation	Performance
	3. Located so as to conform to future development and surrounding environment 4. Detailed locational information required	4. Working face 5. Surface water should be diverted to prevent ponding on landfill surface 6. Cover must meet following criteria: a. 2 ft layer of waste before compaction b. daily cover = 6 in c. intermediate cover = 1 ft where area will not be used within 30 days d. final cover = 2 ft graded and vegetated to prevent ponding and erosion	4. Erosion controlled 5. Leachate controlled 6. Water pollution controlled 7. No special wastes without separate approval 8. Landfill owner is responsible for site for sufficient time to insure recovery of land
Texas	1. No disposal permitted where there is possibility of pollution 2. Disposal near airports subject to FAA review: a. minimum 10,000 ft from turbojet runway b. minimum 5,000 ft from piston aircraft 3. No disposal in areas subject to flooding without protection (50 yr flood) 4. No disposal within 20 ft of boundary of site 5. Disposal within 300 ft of highway subject to Department of Health rules 6. Location criteria vary with 6 different classifications of disposal facilities 7. Groundwater level taken into account 8. Minimum of 500 ft from wells unless adequate protection 9. Facility must be located after consider geology, soil conditions and land use 10. No disposal in surface water	Design criteria for Type I site designed for disposal of municipal solid waste: 1. Access must be limited by fences 2. Supervision during operating hours 3. All-weather access road 4. Working face size must be minimized 5. Surface drainage onto landfill should be diverted 6. Minimum 3 ft soil required under solid waste to prevent leachate per- permeability a. permeability $\leq 1 \times 10^{-7}$ cm/sec b. liquid limit >30 c. plasticity >15 7. Leachate must be collected and treated as required 8. Waste must be conpacted in 2 ft lifts 9. 6 in of cover required daily 10. Final cover to be 2 ft thick, with the top 6 in topsoil, side slopes = 30%, and top slopes $\leq 4\%$	1. No open burning or dumping permitted 2. Litter, vectors, dust, odors controlled 3. Disposal must not cause nuisance or public safety and health hazard 4. Leachate percolation must be minimized 5. Gas migration must be controlled 6. Erosion must be controlled 7. No discharge of contaminated water allowed 8. Surface and groundwater must be protected 9. Bond required for satisfactory closing
Virginia	1. No disposal in State waters 2. Sufficient cover material available	1. Adequate access road required 2. Measures taken to control fire Minimum 50 ft fire break around working area required 3. Livestock not allowed to forage 4. Designed to prevent surface and groundwater pollution	1. No open burning or open dumping 2. Vectors, litter, dust and odors must be controlled 3. No surface or groundwater pollution allowed 4. Hazardous waste disposal permitted only with special approval

(continued)

TABLE 9 (continued).

State	Location	Design and operation	Performance
		5. Cover must meet following criteria: a. daily cover = 6 in b. Intermediate cover is required weekly on cracked or uneven surfaces c. Final cover = 2 ft graded to prevent ponding and erosion	
Washington	Location: 1. Waste may not be disposed in surface or groundwaters without a valid permit 2. Solid waste disposal facilities shall be located so as to properly protect the public health, prevent air and water pollution and avoid the creation of nuisances 3. Waste may not be disposed in floodplain without protection from 100 year flood 4. Generally, 4 ft minimum of impervious soil required between waste and groundwater	1. Fencing required as screening from State and Federal highways 2. Fires must be prevented 3. Supervision during operating hours 4. Adequate buffer area must be surrounding working area 5. Groundwater pollution controls must be provided if needed 6. Surface run-off shall be diverted around disposal site 7. Design for leachate collection and treatment shall be included where precipitation is greater than 25 in 8. Distance between waste and groundwater shall be determined on a case-by case basis 9. Cover must meet following criteria: a. 2 ft layers of waste before compaction b. daily cover=6 in c. final cover=2 ft graded at 20° to 30° to prevent ponding and vegetated to prevent erosion	1. Solid waste disposal facilities shall be operated so as to properly protect the public health, prevent air and water pollution and avoid the creation of nuisances 2. No open burning 3. Litter, vectors, dust and odors must be controlled 4. Leachate must be controlled 5. Erosion must be controlled 6. Noise must be controlled

Criteria Used to Analyze Control Levels

Variations are evident in the level of control exerted by the States over solid waste disposal in coastal environments. States differ in the applicable enabling legislation. All of the 24 states analyzed have solid waste and water laws in one form or another. Coastal zone management acts governing activity in coastal areas are in varying stages of implementation, as shown in the preceding section on Federal Control. Not all those states with new coastal zone programs are indicated in this report because of time constraints and limited availability of information. Wetland or coastal wetland laws are in effect in only 8 of the 24 coastal States, while only Oregon and Maine have facility siting or land use laws. Only State regulatory capacity is discussed here, although further control may be exerted on a local level through such mechanisms as zoning ordinances and building and health codes.

Evaluations of the relative levels of control exerted over solid waste disposal were made on a relative basis rather than by comparison to an absolute standard such as that contained in the RCRA. For example, the decisions as to whether permitting requirements for a solid waste disposal facility are strict or general were made only by examining the requirements of each State in relation to others.

States whose permitting requirements were designated as "strict" (see Table 10) were those that specified required information to be submitted with the permit application. This information included topographical, geographical, hydrogeological, solid waste, and pollution control information as well as operational and final land use plans. A permit requirement designation of "general" was assigned when no specifics were given in the regulations but were left to the discretion of the administering agency. Frequently in such cases, no specific time limit was given. In several cases, no permit requirements were mentioned at all, either because regulations were not yet promulgated, or because a permit was simply not required.

Levels of enforcement capability available to the States were designated as "high," "moderate," or "low" (see Tables 10 and 11). High levels of enforcement capability are characterized by an overriding concern for the environment. This includes frequent investigations and inspections, required monitoring, mechanisms for the issuance of cease-and-desist orders (by the regulatory agencies) or court injunctions, and various mechanisms for modifying, suspending, or revoking permits. A very important component of high-level enforcement capability was a continuing responsibility for the landfill area through a required performance bond or through actual physical maintenance of the site for a specified time period. The criteria for a moderate enforcement capability was a continuing responsibility for the landfill area through a required performance bond or through actual physical maintenance of the site for a specified time period. The criteria for a moderate enforcement capability included all of the same elements of the high level of control, with the exception of post-closure responsibility for the site maintenance. States with low levels of enforcement capability lack mechanisms for the day-to-day control of operations at landfill sites.

TABLE 10. ANALYSIS OF STATE REGULATORY CONTROL OVER MSW DISPOSAL IN A SALINE ENVIRONMENT

State	Applicable Laws	Permit requirements	Level of enforcement	Solid waste penalties		Water penalties		Control over location	Control over operation & design
				civil	criminal	civil	criminal		
HIGH LEVELS OF CONTROL									
California	Solid waste Water Coastal zone	Strict	High	Moderate	---	High	High	High	High (site-specific)
Florida	Solid waste Water Coastal zone	Strict	High	High	---	High	Moderate	High	Moderate
New Jersey	Solid waste Water Coastal zone Wetland	Strict	High	High	High	Moderate	High	Moderate	Moderate
Washington	Solid waste Water Coastal zone	Strict	High	---	Low	High	High	High	High
MODERATE LEVELS OF CONTROL									
Alaska	Solid waste Water	Strict	Moderate	---	High	---	High	Moderate	Moderate
Delaware	Solid waste Water Coastal zone Wetland	Strict	High	Moderate	---	High	Moderate	Low	Moderate
Georgia	Solid waste Water Coastal zone	General	High	Moderate	Moderate	High	High	Low	Moderate
Hawaii	Solid waste Water	Strict	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Maine	Solid waste Water Coastal zone Site location Land use	Strict	Moderate	Moderate	---	Moderate	---	Moderate	Moderate

(continued)

TABLE 10 (continued).

State	Applicable laws	Permit requirements	Level of enforcement	Solid waste penalties		Water penalties		Control over location	Control over operation & design
				civil	criminal	civil	criminal		
MODERATE LEVELS (CON'T)									
Massachusetts	Solid waste Water Wetland	Strict	High	Moderate	---	High	High	Moderate	Moderate
Mississippi	Solid waste Water	General	Moderate	---	Moderate	High	High	Moderate	Moderate
New Hampshire	Solid waste Water	Strict	High	Low	Low	High	High	High	Moderate
New York	Solid waste Water Wetland	Strict	High	High	High	Moderate	High	Moderate	Moderate
Oregon	Solid waste Water Land use	Strict	Moderate	Moderate	Moderate	Moderate	High	Moderate	Moderate
South Carolina	Solid waste Water	Strict	High	Low	Low	High	High	Moderate	Moderate
Texas	Solid waste Water	Strict	Moderate	Moderate	---	Moderate	Low	High	High
LOWS CONTROL									
Alabama	Solid waste Water	General	Low	---	Low	High	High	Moderate	Moderate
Connecticut	Solid waste Water Tidal wetlands	Strict	Moderate	---	---	---	---	Low	Moderate
Louisiana	Solid waste Water	None given	Low	High	High	Low	Low	Low	Low
Maryland	Solid waste Water	General	High	Moderate	Moderate	Low	---	Low	Low
North Carolina	Solid waste Water	Strict	Low	---	Low	---	Low	Low	Moderate

(continued)

TABLE 10 (continued).

LOW LEVELS (CON'T)	Applicable laws	Permit requirements	Level of enforcement	Solid waste penalties		Water penalties		Control over location	Control over operation design
				civil	criminal	civil	criminal		
Puerto Rico	Solid waste Water	None given	Low	High	High	High	High	None given	None given
Rhode Island	Solid waste Water Coastal zone	Strict	Moderate	Low	Low	Low	Low	Moderate	Moderate
Virginia	Solid waste Water	General	Low	---	---	High	High	Low	Moderate

TABLE 11. OVERALL LEVELS OF STATE CONTROL OVER MSW DISPOSAL IN A COASTAL ENVIRONMENT

High level of control	Moderate level of control	Low level of control
California	Alaska	Alabama
Florida	Delaware	Connecticut
New Jersey	Georgia	Louisiana
Washington	Hawaii	Maryland
	Maine	North Carolina
	Massachusetts	Puerto Rico
	Mississippi	Rhode Island
	New Hampshire	Virginia
	New York	
	Oregon	
	South Carolina	
	Texas	

Penalties (if applicable) for the violation of laws relating to disposal of MSW in a saline environment, including permit violations and violations of orders or regulations, varied from nonexistent to criminal charges accompanied by a $50,000 fine and 2-year prison term for each day of violation. Maximum fines of less than $100.00 were considered to be low, and fines of $100.00 to $1,000.00 and/or less than 6 months in jail were considered to be moderate. Larger fines and lengthier terms than these were considered to demonstrate a high level of control.

Location, operation, and design criteria were also analyzed for relative level of control exerted by each State. High levels of locational control were characteristic of States that demonstrated a concern for the environment and sought to avoid damage that could be caused by disposal of waste in appropriate sites. In such States, the hydrogeological location was considered in siting the landfill to prevent pollution of ground and surface waters. These criteria were given in specific terms, such as: No vertical continuity is allowed between the waste and surface or groundwaters. Frequently, a particular depth between the waste and groundwater was specified. States with moderate levels of control demonstrated a concern for the environment, but criteria were stated in general terms such as: Disposal sites should be located so as not to cause pollution. Low levels of locational control were shown by States with minimal pollution control criteria or with locational criteria based only on economic convenience.

Operation and design criteria varied considerably from the high levels (shown by States such as California and Washington with site-specific, rigorous guidelines for the design and operation of sanitary landfills) to low levels (shown by states such as Louisiana and Maryland with very general criteria such as: Water pollution will be prevented). Those States demonstrating moderate-level criteria were those that had rigorous guidelines but that did not focus attention on site-specific concerns.

Analysis of State Control

Assignment of an overall level of control to a coastal State for its regulation of MSW disposal in a saline environment (Table 11) was somewhat arbitrary and depended on all the various control factors taken as a whole--permit requirements, enforcement capabilities, penalties, and criteria for site location, design, and operation. Thus the high levels of control assigned to some States may have been awarded for entirely different reasons. For example, one State may have merited its high rating because of strict penalties for violations and siting and design criteria, whereas another State may have received its high rating for permit requirements and enforcement capabilities.

Whether or not the full effect of the laws and regulations is felt at the sanitary landfill level, of course, depends on the administering agency, funding levels, and political factors. Tables 10 and 11 summarize these analyses of State control.

SECTION 6

DOCUMENTATION OF THE ENVIRONMENTAL EFFECTS OF PAST AND CONTINUING OPERATIONS

LITERATURE SURVEY RESULTS

The primary conclusion to be drawn from the multi-model literature review described in Section 4 is that there has been no comprehensive research performed to quantify the impact of MSW disposal in a coastal/saline environment on the terrestrial and marine environment. This is not to say that the question has not been raised, but rather that the objectives or focus of the research has been oriented so that no definitive statements may be made. Most recent research was oriented towards open ocean disposal of dredged material or sewage sludge. See, for example, the Paras-Carayannis (1973) review of New York Bight Studies. There was also a brief flurry of interest in open ocean disposal of baled, loose, or incinerated MSW. Several excellent technical reports and journal articles were written (First, 1973 is comprehensive), but even these cannot be applied to the question at hand without overstepping the bounds of justifiable extrapolation.

The literature review that follows attempts to summarize the results and conclusions of 78 of the documents reviewed. Two hundred and twenty one documents were identified (see Section 4) for acquisition. One hundred and seventy-one of these were, upon inspection, generally relevant to the general subject matter, and are included in the bibliography. Only seventy-eight of these were sufficiently detailed and germane to the topic of the impact of municipal solid waste disposal in saline environments to be read and reviewed. (Naturally, some of these contained duplicate information, so that only 50 are directly cited in the following review.) Many of the papers contained opinions or conclusions about the overall result of marine waste disposal that were not substantiated by any empirical data. Some of these statements were based on theoretical considerations, and others were completely conjectural. It should not be surprising that this group represented two antagonistic points of view. Either the ocean was portrayed as (1) an essentially infinite sink with a natural capacity to transform and process wastes through biogeochemical pathways that do not differentiate between natural and anthropogenic inputs, or (2) as a poorly understood complex system of interconnected compartments that have been shown to be adversely affected by perturbations thereto. In the latter case, one could therefore extrapolate that coastal water disposal will result in adverse environmental impacts. In either case, the conclusions are less than supportable.

The 78 documents that were considered relevant fell into seven categories.

Category Descriptions

General--

These articles describe in non-quantitative terms the response of the environment in general and coastal marine ecosystems in particular to stress. These studies are often theoretical or philosophical in nature. Only those that illuminate some important aspect of the coastal MSW problem are included. Such articles might also be classified as theoretical ecology.

Ecological--

This group consists of descriptive and quantitative ecological research reports. Most of these studies were described in the formal refered literature and contain specific data on the response of (usually) small segments of the biota to pollutants or other anthropogenic stress. Some of the research was conducted specifically on MSW, but other work that could be reasonably extrapolated was used (e.g., pollutants commonly found in MSW leachate, but derived for the particular study from sewage sludge).

Municipal Solid Waste--

These are engineering or technical reports that describe some aspect of solid waste disposal that affects marine systems, but that was not directly evaluated vis-a-vis such ecosystems.

Waste Quantities--

This group of reports represents statistical compendiums of marine disposal data.

Marine Disposal Input--

Constituting one of the larger groups in terms of numbers of articles, these describe in general terms the effects of solid waste disposal on marine ecosystems. Their usefulness is limited by their being either non quantitative, or primarily concerned with ocean disposal of non-MSW waste streams.

Habitat Depletion/Creation--

These reports do not necessarily deal with MSW disposal, but instead describe the impact of removal of coastal, marshland, and estuarine habitat on the entire marine ecosystem.

Research Needs--

The few authors in this group have recognized the critical lack of well-designed quantitative research on the impact of environmental perturbations on different communities at or near the marine/terrestrial interface. These articles suggest ways of improving our productive capability.

Literature Summaries

The one exception to our finding that there was no research directly slated to our scope of work was a preliminary survey presented at an EPA Office of Water Planning and Standards Conference on Estuarine pollution control and assessment (Feibusch, 1975). H. A. Feibusch defined 11 major solid waste streams, of which residential and commercial refuse are but two, and made up less than 3% of the 150-lb/capita per day disposal rate in 1974. Feibusch conducted a limited telephone survey of senior solid waste management officials. He also found that data concerning the location and number of MSW fill sites in coastal areas were not readily available. New

TABLE 12. ESTUARINE LANDFILLS AND REGULATORY MECHANISMS*

State	Jurisdiction	Date of enabling legislation	Number of existing fills in estuarine areas	New estuarine fills allowed
Maine	P †	12/73	2	No
New Hampshire . . .	P	'73	?	No
Massachusetts . . .	P	4/71	1	No
Rhode Island	P	'74	1	No
Connecticut	P	'71	?	No
New York	P	9/73	?	No
New Jersey	P	'70	?	No
Delaware	P	7/73	None	No
Maryland	P	'70	15##	No
Virginia	P	4/71	1	No
North Carolina . . .	P	'69	20	No
South Carolina . . .	P#	9/71	30±	Yes
Georgia	P	'72	None	No
Florida	P	7/74	?	No
Alabama	P	'69	None	No
Mississippi	P	'74	None	No
Louisiana	P §	?	?	?
Texas	P	'69	Many ††	No
California	L §§	1/73	31	No
Oregon	P	5/71	1	No
Washington	L	'72	?	No

* Source; Feibusch, 1975.

† Primary State Jurisdiction.

Small facilities on Eastern Shore serving total of 20,000 people.

# Can be overruled by any professional-engineer-prepared plan.

§ State must use parish district attorney to prosecute. Since district attorneys are also parish legal advisors, they do not prosecute.

** Counties may assume control by adopting solid waste permit system. Only 4 of 254 counties have done so.

†† Mostly small sites.

§§ Local control.

fills were generally discouraged. The available evidence indicated that Maryland, North Carolina, South Carolina, Florida, Texas, and California may have been and may remain potential problem areas. This information on landfill sites and State regulatory mechanisms is summarized in Table 12, which can be compared to the results of our mail questionaire and regulatory analysis.

Though Feibusch's findings generally agree with ours, we disagree with his evaluation of potential trouble areas. All of the evidence we were able to accumulate points to a general lack of centralized knowledge on the part of State management agencies as to the size, number, or extent of recent and existing coastal MSW operations. It is apparent that the number of sites about which agencies are aware is a function of the availibility of information and the type of permitting system (if any) in operation. It does not appear to be a function of the actual number of such sites. There was also a great deal of discrepancy between data submitted by different officials of the same State.

Wohlschlag and Copeland (1970) pointed out the problems of detecting low-level stress. The response is subtle and often not easily detected. Once observed, it is often impossible to link cause and effect, because the changes often take the form of modification of community structure, such as decrease in species diversity and energy linkages, shorter energy pathways and simplification of trophic structure, and gradual decreases in population size as a result of decreased birth rate and increased death rate. Sublethal effects are also alike at the organismic level and are not easy to detect in bioassays. As Dayton (1972) pointed out, such changes adversely affect community stability by weakening its ability to resist and recover from natural and artificial perturbations in the environment. He has both theoretically and practically developed the concept of foundation in keystone species, whose presence defines the community structure to a degree disproportionate to their numbers. Even small changes in their abundance could drastically alter the coastal marine ecosystem.

Several authors pointed out the importance of the benthos in evaluating environmental stress. Due to their sessile nature, they tend to integrate environmental stress over time. This should be tempered by the fact that ecological response of benthic organisms has been shown to be more closely related to physical and chemical parameters of sediments than to water quality (Storrs et al., 1969). This makes development of scientifically defensible criteria difficult because valid data on physical and chemical forms of pollutants and their fates in complex coastal systems are scarce (U.S. Environmental Protection Agency, 1972).

The largest single category of work reviewed was the ecological studies, although the ability to extrapolate from many of these single-pollutant, laboratory or controlled field-type experiments, to real-world conditions, is not good in many cases. Often, the work was stimulated by disposal problems other than MSW, but common pollutants are involved.

A good example of this is the salt marsh sewage sludge enrichment experiments conducted by Valiela *et al*. (1973, 1974, 1975) and Van Raalte *et* al. (1976) on Cape Cod. These experiments showed that both anaerobic marsh muds and organisms such as clams and oysters took up and retained heavy metals and nutrients. Primary productivity was increased with no apparent detrimental impact on standing crops or community functioning. Growth and survival of bivalve mollusca was not seriously affected, but diversity of epibenthic algae decreased. Adsorption to soil particles and plant uptake were seen as the primary vehicles for metal and nutrient retention.

Other research demonstrated heavy metal accumulation in phytoplankton as well as toxicity of metals to bivalves (Lear and Pesch, 1975). However, different forms have widely varying effects (Segar and Cantillo, 1975).

Boyt et al.(1977) have shown that freshwater wetlands can reduce plant nutrients in overlying waters by 90% to 98%, with a corresponding dropoff in bacteria. Several authors have reported on the bactericidal effect of seawater, although at least one study (Won and Ross, 1973) found organic matter to increase bacterial survival in seawater. Nitrification and NO_3 reduction by both intertidal and fresh and saltwater marsh sediments is also well known (Bahlol, 1977 and Patrick, et al., 1976). The former study showed nitrification of up to 11,000 mg NO_3-N/m^2 when ammonia enriched seawater was used, while Patrick's work on salt marsh muds in Louisiana clearly demonstrated the ability of the reducing anaerobic zone to denitrify up to 7.41g/N/hectare per day. These high rates are achieved in high organic matter soils with very thin oxidized zones. The studies of Pratt et al. (1973) on ocean disposal of baled solid waste are not applicable only to open water bale fills, although they may be relevant to the extent that baled waste is placed in water directly adjacent to the coast. These investigations found a very high BOD in interstitial waters. All O_2 was consumed in 6 to 8 days. Increasing H_2S production was found after 7 weeks and NO_3 was completely gone within 1 week. Phosphate increased to 22 to 32 mg/l and stabilized at that point. Total organic carbon and turbidity increased with time. Initially high hydrogen production was replaced by lower CH_4 and H_2S evolution, which could, however, reach toxic levels. The waste bales were not hospitable to many organisms because of low O_2 and high H_2S, and therefore degradation might be expected to be slow. Pratt and his coworkers summarized their conclusions on organismic impacts as follows:

1. Only infaunal species tolerant to low oxygen levels and the presence of H_2S will colonize the waste.
2. Both infauna and epifauna will be limited if the oxygen in the overlying water falls below 2 ml/l. This will be a function of rate of oxygen uptake, waste surface area, and the oxygen content, velocity, and turbulence of overlying water.
3. The effect of H_2S on epifauna and motile animals will depend on the dispersion rate in the overlying water. H_2S will be present in waters downstream from the dump site, but little information is available on its attraction or repulsion of motile animals.
4. Newly deposited waste will attract scavengers; however, this attraction may be diminished after a period of months.
5. Fouling of the deposit may be restricted to species resistant to H_2S. Little fouling will occur in deep waters, regardless of

the deposit surface environment. It is not possible to state whether wood-boring species will be attracted to waste.

6. Bacteria on the waste surface may provide food for deep sea animals.

Actual field studies by Pearce (1972) of deep ocean baled waste disposal did show very gradual infestation by infauna (polychaetes) and epifauna, reducing conditions, and very limited degradation.

A group of engineering-type reports describing various aspects of MSW disposal and leaching are relevant in that the effect of leachate discharge to surrounding waters is one of the reasons advanced for restricting waste disposal. Chian and DeWalle (1976) reviewed the factors affecting leachate generation and quality. Their work showed that the inorganic and organic constituents of leachates varied on a day-to-day basis, with a total range of over three orders of magnitude. The factors they have found to affect leachate composition quantitatively are: Age of fill, composition and size of waste stream, degree of compaction and moisture content of waste, rainfall infiltration, temperature, landfill geometry, and sampling and analytical methodology. A final undefined factor, leachate environment interaction, was also mentioned. Griffen et al. (1978) examined one of these factors, the attenuation of leachate by clays. Their column studies showed that Pb, Cd, Hg, and Zn were strongly attenuated, that K, NH_y, Mg, Si, and Fe were moderately attenuated and that Cl, Na, and COD were unaffected. The mechanism of heavy metal removal was precipitation, while other constituents were bound by cation exchange. The authors cautioned against extrapolating their results directly to all fills, because the adsorption/mobility of any one element would be directly affected by leachate characteristics that vary widely, such as pH and concentration of other solutes.

Two authors (Bogost, 1973, and Anonymous, 1973) describe the results of an experimental pilot-scale placement of baled MSW directly into coastal lagoons. They appear to be describing the same experiment, but no details or hard data are presented. The qualitative results described show that little decomposition occured over 15 months and that lagoonal water turned color and became anoxic, although recovery began within several months.

The consulting firm of Eberlen and Eberlen was asked by New York City (U.S. Environmental Protection Agency, 1972) to investigate the feasibility of a diked sanitary landfill in Pelham Bay. They found that in general, decomposition and leachate generation and stabilization proceeded more slowly in landfills placed in swamps, wetlands, or groundwater, because of the rapid development of anaerobic conditions and slow water movement. To prevent this, and also to prevent extremely rapid leaching and flushing of pollutants into the bay by tidal action, the engineers proposed a so-called dry landfill: diking of the fill area, sealing to prevent infiltration, and treatment of leachate before discharge. They predicted the leachate quality, based on a 1-million-gallons/day production rate, as shown in Table 13.

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TABLE 13. ESTIMATED LEACHATE QUALITY, PELHAM BAY SANITARY LANDFILL

Constituent	Concentration of Leachate Average mg/l	Concentration of Leachate Peak mg/l
Biological oxygen demand	200	1,200
Chlorides	15,000	15,000
Suspended Solids	100	500
Iron	100	350
Copper	1	5
Nickel	0.5	1
Zinc	10	100

Most "documented" quantities of marine waste disposal relate to oceanic disposal of either sewage sludge or dredge spoil, or such documentations quote figures on offshore barging of MSW (Mantell, 1975, Cox, 1975) that either rely directly on Gunnison _et al_.'s 1970 study or update it. Variously, 26,000 tons in 1968, declining to 240 tons in 1973; or, a total of 159,000 tons was dumped from 1931-72. Also, 20,000 tons of cannery waste (similar in content to MSW) and 6,000 tons of vessel garbage were dumped in U.S. coastal waters off the coast of California.

Other figures on coastal waste disposal are based on extrapolations from various land disposal data, demographics, or economic activity figures. Riley (1972) reported that 376,000 tons of MSW were generated by 460,000 persons in coastal counties of North Carolina, but this figure included inland U.S. coastal disposal sites. Hudson et al. (1974) stated that historically, MSW has been an insignificant fraction of all marine disposal operations. The Council on Environmental Quality (1970) estimated that 65 million tons of MSW are deposited in coastal areas yearly; this amounts to about 34% of the U.S. total.

Two surveys were region-specific. Rorholm _et al_. (1969) did not have volume or tonnage figures, but rather used economic measures of solid waste disposal in Narragansett Bay, Rhode Island. He found that $7.2 million was saved in 1967-68 by using coastal sites versus more valuable inland areas, and the total economic activity generated by coastal waste disposal was $12.2 million. In 1976, the Gulf Coast Waste Disposal Authority with Section 208 Clean Water Act funds, surveyed all waste disposal sites in the Houston-Galveston, Texas area. They found eight commercial and municipal sites accepting MSW on or adjacent to tidal waters. These ranged in size from 8 to 196 acres and handled 230-276,000 yd^3 per month. Table 14 summarizes the data.

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TABLE 14. HOUSTON - GALVESTON AREA LANDFILL DATA

Site name	Size (acres)	Volume (yd3/month)	Available capacity
Browning-Ferris Industries	196	276,000	5-6 years
G.B. Hazelwood	22	21,600	7 years
Jacinto City	20	--	1 acre
Harris County #3	34	15,000	1 year
City of Galena Park	25	2,400	15-20 acres
City of Bellaire	75	6,000	7-8 acres
City of Baytown	50	15,000	5 acres
City of W. University Place	73	230	25-27 acres

The papers on coastal waste disposal describe inferred or hypothetical answers to the question "what is the effect of MSW disposal on the coastal environments" without empirical verification. For example, the National Industrial Pollution Control Council (1971) postulates four major and several corollary mechanisms by which baled solid waste deposited on the ocean might cause pollution. They can be modified to provide a conceptual model of the coastal land/bale fill system:

1. Physical reappearance of refuse.
2. Elution of discarded soluble materials.
3. Elution of decomposition products of refuse.
4. Interference with biological activity.

Cole (1973) orients his classification of impacts toward direct effects on economically exploited species:

1. Killing.
2. Interference with bio-processes resulting in diminution of size, abundance, quality or availability.
3. Contamination with persistent toxics.
4. Tainting so as to be unpalatable and/or unsalable (temporary).

Smith and Ward (1972) feel the most serious problem is the indirect effects of filling coastal waters and causing changes in flushing and circulation patterns, whereas Schubel (1976) feels that biostimulation in coastal areas is not a serious problem. He believes that its results will primarily manifest themselves in an increased rate of primary production by the normal population without shifts in the species composition. Preliminary confirmation of this hypothesis may be found in Corliss and Trent (1971). They compared phytoplankton production in housing development canals,

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natural marshes, and open estuaries to see if phytoplankton compensate for reduced productivity of seagrasses and emergent vegetation in deeper waters. They found that both gross and net carbon production was increased in the canal phytoplankton community. They did not, however, look at species composition/distribution.

Considering the overall capacity of the marine environment to process wastes, Bascom (1977) is an optimist. His position is that oceans contain millions to billions of tons of heavy metals, plant nutrients, etc. If wastes are dispersed properly, it is impossible for anthropogenic sources to be significant. Feldman (1970) had earlier pointed out three fallacies in the argument for the ocean as an infinite sink):

1. Lack of detailed knowledge of input, inventory, or removal of most trace materials,
2. No detailed knowledge of trace material/biota interactions, and
3. Assumption that trace metals deposited in neritic and estuarine waters will be mixed and eventually deposited in deep ocean sediments.

Van Hooke (1977) points out that soils and sediments, while serving as major sinks for leachate constituents, can also release them to the biosphere. Metabolism by microorganisms can change the toxicity and availability of elements, and once released, aquatic organisms show a greater tendency to bioconcentrate. Synergistic and antagonistic interactions are also important in such a mobile and well-mixed medium.

Reed (1975) pointed out this same possibility in a wide-ranging review of oceanic waste disposal. He considered synoptic impacts and synergisms to be merely speculative unknowns. He pointed out the deficiencies of previous research, in that it was very goal oriented: determination of causes of specific pollution events or technical/economic feasibility studies. In this same vein, he cited three classes of impacts of saline MSW disposal: market, sociological, and ecological, with the former being very poorly understood. He felt a need for biological indicators of pollution in near-shore waters because:

1. Vast volumes dilute and/or disperse pollutants to very low concentrations,
2. Different physical properties concentrate suspended and dissolved material in estuaries, and
3. Precipitation and bioaccummulation are two important concentrators, both primarily depositing material to benthos. (Unfortunately, the same property makes benthic organisms poor bioindicators for short term events.)

The coastal zone is a primary zone for mobilization of MSW leachate, as

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shown by Schneider (1970). He pointed out the high leachate pollution potential of sites where the water table is at or near the surface, where there is direct contact between waste and water, or where permeable materials and/or steep hydraulic gradients allow rapid movement of dissolved constituents. All or some of these conditions are present at many coastal sites.

Although the direct effects of MSW disposal in coastal saline environments are not well known, one of the indirect effects, habitat depletion or physical alteration, is well known to be one of our most significant ecological problems, with far-reaching indirect effects of its own. As early as 1969, Bagge pointed out that changes in estuarine communities are usually due to such independent physiographic changes as alterations in drainage, erosion, sedimentation, and fresh water inflow. The National Estuarine Pollution Study (1970), summarizing other research, concluded that filling coastal areas could upset sedimentation patterns, with negative effects on recreation, fishing, navigation, wildlife populations, and water quality. Worse, such physical alterations are usually permanent. The National Estuary Study (1970) also cited habitat modification/depletion by landfill to be a major problem resulting from human activity. Fish and wildlife field personnel felt that 73% of our estuaries were moderately or severely modified.

The Jamaica Bay Environmental Study Group (1971) focuses on a productive estuarine and marshland ecosystem where MSW disposal has resulted in extreme modification of the environment. In 1965, 950,000 tons of MSW were deposited in Queens, mostly in Jamaica Bay marshlands. Between 1907 and 1971, 75% of the bay's marshlands were lost, primarily as a result of landfill disposal of MSW for the five boroughs in New York City; the decade 1954-64 saw marshland acreage drop 33%-98%. At the same time, dredging deepened the bay, increased residence time, and decreased flushing. Such a decrease in area and impairment of circulation drastically decreased the productivity of the bay, where commercial fish catches decreased 80%-90%.

Buckley's 1971 analysis of the viability of the Hudson River Estuary points to low salinity marshlands at the head of the saltwedge as the critical waste-processing and organic-matter-producing element. Physical change was seen as the major threat to long-term viability and productivity of the ecosystem. Filling of marshes and shallows in the low salinity (1% to 15%) recycling zone has increased the volume of the tidal prism. Oxygen and production drops as turbidity shades phytoplankton and as rooted and emergent vegetation is reduced by filling of shallows. Detrital production also drops as plant and epiphytic algae production falls off.

On the other side of the coin, there is a good possibility that properly designed, sited, and operated fills could be used to convert marshland to other productive coastal habitat. The work of Windom et al. (1974), Dunstan et al. (1975), Johnson and McGuiness (1975), and many others has clearly documented the possibility of artificial and natural establishment of Spartina and other vegetation on fills. Cammen (1975) found that within 2 years, such marshes resembled natural areas in appearance and in Spartina production, and that with a good match of ele-

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vation, sediment particle size, and sedimentation rate, coupled with a mature marsh fauna in reasonable proximity, a natural marsh fauna would establish itself rapidly. Passavant and Jefferson (1976) were able to trace natural succession on dredge spoil fills in Florida through stabilization of sediment, herbaceous and woody plant invasion, and canopy closure to a high diversity climax community essentially identical to the natural island climax for the region.

Several authors have recognized the lack of predictive capability concerning the impacts of coastal waste disposal, which is a result of limited knowledge about the biological, chemical, and physical variables of coastal systems:

> .... it is no exaggeration to state that the environmental effects of past and present dumping operations are, with the exception of those dumped in the New York Bight and off Cape May, Delaware, not even qualitatively known, much less measured accurately (Brown and Shenton, 1971).

For the most part, Brown and Sheuton pointed out the types of data required to assess and monitor environmental impacts, although some have pointed out philosophical, attitudinal, and institutional shortcomings that have hindered development of such knowledge.

Bascom (1978), in support of his position that properly dispersed wastes can be processed effectively by oceanic biogeochemical cycling, states that water pollution does not exist unless the ecosystem is damaged. He sets out three evaluation criteria: water must be safe for contact recreation, seafood must be edible; and sea life must be unharmed. Unfortunately, application of these criteria will not result in adequate protection of coastal ecosystems, because only the first two can be operationally defined, and strict adherence to them will not result in achievement of the third, which is at present indefinable. Bascom has, however, pointed out some of the data requirements necessary to quantify man's influence on the ocean:

> Physical data--net current movements and partioning between tidal, wave, wind, and oceanic components, temperature, and particles.
>
> Chemical data--major constituents (oxygen, nutrients), trace elements, and hydrocarbon concentration, distribution, and speciation.
>
> Biological data--types and numbers of organisms, abiotic requirements.
>
> Public health data--chemical and biological factors causing health problems.

The appropriate techniques for determining some of these parameters, or their overall significance, is not universally accepted within each field, though.

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Simpson (1978) approached the problem in a more useful manner, describing several functional systems that must be adequately characterized to understand and control the effects of any oceanic discharges:

Source - determine components and quantify physical chemistry, toxicity, and speciation of waste;
Environmental - supplement water masses, biota, and currents by remote sensing and continual monitoring;
Biotic impact - determine undivided species as well as communities, life cycle effects, and indicator species;
Waste dispersion - determine currents and diffusion;
Environmental quality indices - compile multiparameter statistics.

Achrem et al. (1973) also addressed the question of data requirements necessary for informed waste management decisions: Site specific evaluations, use of existing data, and baseline data collected specifically to evaluate disposal impacts and operational monitoring. Reed (1975) pointed out, though, that there are two basic types of monitoring and three types of recordkeeping encountered in waste disposal studies:

1. Environmental monitoring, which is designed to determine short and long-term impacts by means of periodic observation and sampling. and the goal of which is to set up waste and environmental criteria of siting; and

2. Regulatory monitoring which satisfies jurisdictional and regulatory requirements to determine statutory compliance.

Reed points out that the totally insufficient effort placed on environmental monitoring makes the regulatory monitoring of limited value because the former is needed to set up relevant criteria. Most of the MSW monitoring effort is placed in the latter category. Once monitoring requirements have been set up, a further complication is encountered. Most often, results are submitted as required without any further evaluation. After a period of time, monitoring may cease altogether. Only rarely is there evidence that such data are regularly received, evaluated, and acted upon.

The end result of this literature review, then, is to substantiate conclusions made 5 to 10 years ago—that little is known quantitatively about the impact of coastal MSW disposal on environmental systems. The only well documented effect is habitat depletion. Because of the assimilative capacity of estuaries and the large dilution and dispersion potential in most coastal areas, it may be that this is the most serious problem to be encountered. The problem is subtle, incremental, and far-reaching, with major secondary impacts linking the coastal MSW disposal problem to waste water treatment, water pollution, ecosystem productivity, and energy flow and fisheries management.

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SITE VISIT RESULTS

The solid waste management offices of seven States were selected as visiting sites based on the extent and availability of monitoring information indicated by the questionnaire survey responses and subsequent telephone followups. The information obtained on the coastal solid waste disposal facilities in the selected States is presented in Appendix C and corresponds to the model site visit checklist presented in Appendix B. Summaries of the types of data obtained for the seven States follow:

California

The State of California maintains exceptionally high levels of control on landfills that are located within saline environments. The California Regional Water Quality Control Board has established waste discharge requirements for nonsewerable waste disposed on land which provide specific operating requirements for sanitary landfills. The regulation of waste disposed on land is undertaken through the establishment of a statewide disposal site and waste classification system. The classification of all sites is based on the geologic/hydrologic features of the disposal area and the capability for protection of surface water and groundwater quality. The State requires that the individual operator provide monthly monitoring reports that include monitoring data, results of observations and analysis, and discussion of violations found and corrective actions taken or planned. Onsite inspections are regularly conducted, and control is rigorously maintained. An evaluation of past historical records and analysis of current disposal practices indicate that significant upgrading of existing landfills has taken place over the past several years.

Site visits to the California landfills reaffirm the importance of considering geologic and hydrologic conditions to prevent pollution. For example, the unique characteristics of San Francisco Bay mud (its low permeability) play an integral role in the prevention of groundwater contamination by leachate. Efforts during the past years to prevent horizontal movement of leachate has assured the maintenance of high quality receiving waters.

Connecticut

Hydrogeological data were available for both sites investigated in Connecticut, Fairfield and Milford, though in considerably greater detail for the Milford Landfill, which has been studied for its potential to be converted to a State park. At this latter site, extensive monitoring of methane gas levels has been documented, with conclusions being that natural water bodies adjacent to the site prevent lateral migration of gases. Water quality and leachate monitoring results were available for both sites.

Maryland

Information concerning Maryland coastal waste disposal sites varied considerably. Many sites had been unused for years, so that no information

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was available. In some cases, there was no record of past waste disposal activities or types of waste disposed in areas presently utilized as municipal sanitary landfills. In recent years, however, the Maryland Division of Solid Waste and the Maryland Water Resources Division have been acquiring data and information in connection with permit applications, conversions to sanitary landfill operations, existing operations and site closures. The Division of Solid Waste supplied geological, hydrological, topographical, and operational information. Some leachate analysis data were available on one of the researched sites; no documentation of the effect of disposal in the saline environment was available, however. The Water Resources Administration furnished water quality data in the sites researched. Again, no analysis was available on the effects of disposal on the saline environment.

Louisiana

In general, site-specific geological, hydrological, or water quality data were lacking. Permit applications generally describe the areas to be filled and the proposed operating scheme, in terms of equipment to be used, rate of filling, type and depth of cover to be applied, etc. It must be noted that the marshland fill projects identified all lie at about the same elevation, and in the same hydrologic and biologic environment. Monitoring efforts consist of periodic inspections to confirm adherence to modified sanitary landfill operations, with subsequent administrative attempts to persuade operators to eliminate open dump conditions.

New Jersey

A good amount of planning activity concerning the management of the sanitary landfills in the Hackensack Meadowlands District of New Jersey is taking place. With plans to close all of these landfills by the end of 1979, the Hackensack Meadowlands District Commission is responsible for their restoration and monitoring activity.

Extensive background information was found to be available on the underlying geology of all five of the sanitary landfill sites that were researched in the Meadowlands area. In addition, hydrological information was readily available from studies completed on the biozones of the marsh areas. Each biozone was delineated according to the salinity level.

In the town of Kearny, periodic water quality sampling data were available, along with methane sampling data for two of the three sites operated by the Municipal Sanitary Landfill Authority. Water quality data were also available for the Bergen County Landfill in Lyndhurst, along with total heavy metals and available heavy metals data for 1974. In Kearny, no adverse effects from metals have been detected after 10 years of monitoring, and the levels measured within the native crabs have been found to be within the FDA limits for contaminants.

New York

Hydrological and geological data on Long Island are well documented.

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with U.S. Geological Survey reports specifically dealing with the Islip and Babylon sanitary landfills, which are in the coastal zone. Unfortunately, however, there is no indication of the effects of the landfills on the coastal ecosystems. Both leachate and water quality monitoring data are available for these two sites. A report by Henderson and Casey, Consulting Engineers, documents the hydrogeological status in the vicinity of the North Hempstead, Long Island, sanitary landfill. Leachate monitoring data are available for this site, and four monitoring wells are installed to monitor the existing water quality.

South Carolina

The EPA Region IV Office in Atlanta has generated water quality data from six locations in or adjacent to the Ashley River landfill. These data are the result of short-term monitoring efforts in the Ashley River and within drainage ditches receiving direct leachate discharge. For the most part, conventional pollutants were measured (BOD, TKN, NH_3, NO_3, PO_4, and conductivity), although four sediment analyses and three reasonably complete sets of leachate analyses are available. No other landfill site has any detailed monitoring on site description.

From these site visit investigations, an extreme variation in the level of monitoring data availability was discovered. Variations existed in the level of the States' environmental awareness, operation of monitoring programs, and operation of the landfills themselves. In some cases, data obtained from monitoring programs were extensive but did not serve any useful purpose, whereas in others, the information obtained from the monitoring programs was utilized in an environmentally sound solid waste management system.

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APPENDIX B. SITE VISIT INFORMATION OBJECTIVES

1. Site characteristics

   a. Location

      Longitude/latitude
      USGS topographic quadrangle

   b. Hydrology

      Surface water
      Groundwater level, rate and direction of flow
      Tidal effects
      Salt water wedge
      Infiltration rate

   c. Geology

      Depth to bedrock
      Soils - porosity

2. Landfill operation and effects

   a. Operation

      Area used - existing and closed landfills
      Duration of time in operation
      Amount and type of material deposited
      Volume and amount of compaction

   b. Effects - monitoring data if available

      Leachate generation, movement, attenuation and effects
      Surface water quality - COD, BOD, heavy metals
      Bioassays
      Gas generation, movement and effects

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APPENDIX C. DISPOSAL SITE INFORMATION OBTAINED DURING SITE VISIT

California

Site: Palo Alto Refuse Disposal Area,* Palo Alto, California--

I. Site characteristics
  A. Location
    NA †
  B. Hydrology
    Surface (perched) layers of bay mud are in direct communication with the bay, and two aquifers are confined/semi-confined below. Surface waters have been extensively modified by changing drainage patterns. Many of the water bodies have become stagnant and eutrophic.
  C. Geology
    The soil/surficial materials consist of bay mud interspersed with sand/silt/clay lenses. These impermeable clay layers have protected both the upper and lower aquifers.

II. Landfill operation and effects
  A. Operation
    This modified sanitary landfill, will be converted to sanitary landfilling in 40 additional acres.
    1. Area - ±100 acres; the operators use the landfill method of placing material directly onto excavated mud/groundwater area up to 22 ft thick.
    2. Time in operation - 1930's to 1954.
    3. Amount/type of material - Site receives 200 to 250 tons/day.
  B. Effects
    1. Leachate
      Water quality testing shows substantial contamination of brackish shallow aquifer, but impermeable clay layers have protected both upper and lower aquifers.
    2. Water Quality Monitoring
      ph...2.9-9.1
      PO_4...0.21-8.54 mg/l
      NO_3...0.01-2.86 mg/l

---

*Information obtained from Draft Environmental Impact Report by Engineering Science, Inc.

†Data not available.

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Cl	412-20,060 mg/l
COD	5-960 mg/l
BOD	7.8-19.5 mg/l
Fe	3.2-29
TDS	1.1-44,900

3. Bioassays - NA.
4. Available Heavy Metals - NA.
5. Total Heavy Metals - NA.
6. Methane - NA.

C. Other comments

1. Baylands area has been extensively modified and contains salt marsh, fresh marsh, meadow, disturbed areas, and and tansition zones.

2. The most serious impact of previous operations has been habitat depletion. Physical alteration of the present expansion site is a salt flat resulting from subsidence and the restructuring of circulation.
3. The completed fill is grassland and bare soil.

Site: Richmond Sanitary Service West, Contra Costa County, California--

I. Site characteristics

A. Location

City of Richmond, north of Route 17 and west of 3rd St. Site is bordered on the west by San Pablo Strait.

B. Hydrology

Site is adjacent to San Pablo Bay near the point where San Pablo Creek and Costro Creek enter the bay.

C. Geology

Area has characteristic Bay mud underlying the site. This is a tight clay material with a permeability on the order of 1×10^{-6} cm/sec.

II. Landfill operation and effects

A. Operation - Sanitary Landfill

1. Area - 900 acres.
2. Time in operation - NA.
3. Amount/type of material - January to March 1979, Class I liquid wastes (881,000 gal.plus 12,354 barrels).
   Sludge - 36,000 yd^3.
   Class II & III municipal type waste, 52,000 tons.

B. Effects

Environmental monitoring involves series of water quality data as well as monthly visual inspections.

Table C-1 shows groundwater monitoring data for Q stations, which encircle those areas receiving municipal waste.

TABLE C-1. RICHMOND SANITARY SERVICE SELF MONITORING PROGRAM
QUARTERLY REPORT (CALENDAR YEAR 1979) PART B.
GROUNDWATER MONITORING, 2 & 3 CLASS II & III DISPOSAL AREAS, Q STATIONS

	Q station										
Variable	Q-1	Q-2	Q-3	Q-4	Q-5	Q-6	Q-7	Q-8	Q-9	Q-10	Q-11
Depth to water (ft.)	2.5	6.0	5.5	5.5	3.5		4.25	4.25	3.75	5.25	9.75
Color	800	70	700	130	180	TOO	250	200	350	500	300
Chloride (mg/1)	4,700	9,980	6,000	10,800	14,500	MUDDY TO GET	7,300	9,600	11,600	2,600	7,700
Chemical oxygen demand mg/1	1,180	1,400	1,040	360	1,280	TO WELL	360	820	1,360	760	1,220
Total kjeldahl nitrogen as N (mg/1)	156.0	30.8	32.2	19.6	11.2	FOR SAMPLE	47.0	12.3	52.6	207.0	68.3
Nitrate nitrogen as N (mg/1)	<1	<1	<1	<1	2.35		<1	<1	<1	<1	<1
pH (electrometric units)	6.8	6.8	7.1	7.2	7.2		7.1	6.6	6.6	6.7	6.7
Conductivity µmhos/cm	17,800	24,400	18,180	25,300	27,800		20,400	25,600	27,000	10,600	21,200
					Q STATIONS						
Depth to water (ft.)	2.5	4.75	6.6	3.56	3.5		5.25	9.75	4.25	--	--

Connecticut

Site: Fairfield Landfill, Town of Fairfield, Connecticut (Flaherty-Giavara, 1977).--

I. Site characteristics
  A. Location
    On One Rod Highway, adjacent to Pine Creek.
  B. Hydrology
    1. Marsh.
    2. Surface water - site is bordered by Pine Creek on two sides.
    3. Groundwater flows toward Long Island Sound.
    4. Water table averages from 2 to 4 ft above mean sea level (msl).
    5. Groundwater is characterized by low hydraulic gradients and no lateral inflow. Most of it moves laterally away from the center of the landfilled areas in a shallow, predominantly layered flow.
  C. Geology
    1. Glacial marine deposits of sand and gravel overlie a granitic gneiss bedrock formation.
    2. At the southern end, a 3 to 5 ft marsh layer exists above the sand and gravel. II. Landfill operation and effects
  A. Operation
    Area method of cell construction is used with 15 to 20 ft. lifts.
    1. Area - NA.
    2. Time in operation - Approximately 25 yr.
    3. Amount/type of material - Approximately 40,000 tons/yr of unprocessed residential, commercial and industrial waste.
  B. Effects
    1. Leachate
      a. Groundwater of site showed evidence of leachate (iron=35.8-66.5 mg/l COD=319-745 mg/l).
    2. Water quality monitoring
      a. Data from a Flaherty-Giavera study (January 1977) showed high levels of specific conductance, total solids, sodium, and hardness (CaCO3) west and south of the site in Pine Creek.
      b. COD readings ranged from 175 mg/l in a retention pond to 310 mg/l southeast of the site outside the diked area.
      c. Total coliforms were generally less than 1, but they reached 150 in one sample.
      d. DO=9.6 to 11.6 mg/l.
    3. Bioassays - NA.
    4. Available heavy metals - NA.

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5. Total heavy metals - NA.
6. Methane - NA.

Site: Milford Landfill, Town of Milford, Connecticut--

I. Site characteristics

A. Location

From East Broadway, south to Nettleton Avenue, west to the Great Creek end of Cooper Street, and east to a distance of approximately 800 to 900 ft north of the shredder and maintenance complex.

B. Hydrology

Groundwater is present and flowing in the outwash sediments of silty fine sands to gravel. The area acts as a recharge zone for local infiltration, causing radial outflow of the groundwater from the site and pollution of the waters. The groundwater below the disposal area was found to be mounded to a maximum elevation of 8 ft above the former wetland elevation which was estimated to be an elevation of 3 to 5 ft. Waters that formerly discharged to the wetland now are part of the deep flow under the former wetland and discharge to Long Island Sound or other discharge areas closer to the Sound. The daily rate of flow is 0.1 to 0.25 ft/day. Groundwaters originate from precipitation falling on the landfill surface, and the average annual precipitation is 48 in. The infiltration rate on the landfill has been estimated to be 15 in/year and site runoff is 7 in/year.

C. Geology

The landfill site originally consisted of a wetland drained by tidal streams that developed between a large hillside to the northwest and a beach bar to the southwest. It is underlaid by variable layers of outwash sediments consisting of silty, fine sands to gravel. The underlying bedrock of metamorphic rocks generally slopes from northwest to southeast, ranging in depth from 0 to 35 ft to more than 60 ft near the beach. Near the landfill and shredder complex is a 3 to 8 ft thick laterally discontinuous layer of medium to course sand. This overlies a layer of fine sand to dense gray brown silt and fine sand ranging in depth from 0 to 60 ft, which overlies an 8 to 10 ft thick basal fine to coarse sand and gravel layer. Organic silts and clays of 0 to 20 ft deep exist in the wetland areas.

II. Landfill operation and effects

A. Operation

Before 1964, burning was probably frequent; between 1964 and 1971, the landfill operation was converted to one that included covering with soil. A waste shredder shredded a portion of the waste stream from 1971, upon its completion, until 1974, when it was destroyed by an explosion.

1. Area - more than 100 acres.
2. Time in operation-1940's to June 1977.
3. Amount/type of material - 50% paper and rags, 20% wood, 20% soil, 5% glass and 5% metal.

B. Effects

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1. Leachate

The quality of the groundwater is improving and is expected to continue to do so, since no additional refuse is being deposited at the site. Surface waters directly receiving leachate include Great Creek, Fletchers Creek, Long Island Sound, and the Nettleton Avenue drainage channel. Leachate concentration decreases with time and distance from the site (see Table C-2).

2. Water Quality Monitoring

Groundwater from the landfill site is contaminated with soluble dissolved chemical constituents leached from the solid waste by rain infiltration in the unsaturated portion and by through-flowing groundwater in the saturated lower portion of the landfill (see Table C-2).

3. Bioassays - NA.
4. Available Heavy Metals - NA.
5. Total Heavy Metals - NA.
6. Methane.

No detectable levels of combustible gas were found in the wetland areas associated with Great Creek, Fletcher's Creek, or in the peripheral wetlands areas that are adjacent to the residential areas of Cooper Avenue and Pearl Street. The wetland and channel between the landfill and Nettleton Avenue to the west act as an effective hydraulic barrier to the horizontal migration of gas. To the south along East Broadway and to the northwest at Mayflower Place, no detectable levels of combustible gas are found at either the surface or within the soil, as a result of the hydraulic barrier. Study conclusions are that the saturated soil and standing water around the perimeter of the entire solid waste disposal area contain the landfill gases.

Louisiana

Site: Browning-Ferris Industries/East and West St., Charles, Louisiana--

I. Site characteristics
   A. Location
      North side of U.S. Highway 61, west of New Orleans Airport.
   B. Hydrology
      Tidal wetland.
   C. Geology
      Organic clays underlaid with sand and aquifers at 200, 400, 700 and 1,200 ft.

II. Landfill operation and effects
   A. Operation
      1. Area - NA.
      2. Time in operation - NA.
      3. Amount/type of material - 115,000 yd^3 MSW/year.
   B. Effects
      1. Leachate - NA.

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TABLE C-2. LABORATORY ANALYSES OF AREAS ADJACENT TO AND UNDERNEATH THE MILFORD LANDFILL, MILFORD, CONNECTICUT

Variable	Range of surface water samples†* 1973	1977	Range of leachate-bearing groundwater samples†* 1973	1977
Biological oxygen demand	0.0-130	2.0-20.5	---	---
Chemical oxygen demand	---	176-576	40-12,400	---
Nitrate as N	0.10-1.0	0.23-1.9	---	<0.10-3.05
Ammonia as N	0.18-35	0.15-42.5	0.045-242	0.55-124
Organic nitrogen	0.44-13	0.03-7.3	---	---
Chlorides(Cl)	20-3,300	140-5,000	175-1,500	232.-7774.
Sodium(Na)	---	14.5-2430	135-630	---
Aklalinity($CaCO_3$)	20-880	<2.4-610	10-1,720	320-1,230
Dissolved Iron(Fe)	0.8-42	.06-32.9	0.14-63	---
Dissolved manganese(Mn)	0.15-3.2	0.31-6.45	---	---
Coliform(MF/100ml)	---	0-1,000	0.00-130	---
Total dissolved solids	---	197.0-2889.0	1,659-19,410	---
pH	6.6-8.0	---	5.3-7.15	6.2-6.7

* Ranges reflect the highest and lowest amounts detected among 5 to 11 monitoring sites.

†Results are in mg/l, unless otherwise specified.

2. Water quality monitoring - NA.
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

C. Other comments

Considerable State effort has gone to remedy open dump conditions; its effectiveness unknown, however.

Site: Jefferson Disposal Co., Inc., Jefferson St. Charles Parish Landfill, Louisiana--

A. Location

North side of U.S. Highway 90 West, T-13-S, R-22-E

B. Hydrology

Tidal wetland.

C. Geology

Impermeable organic clay (30 to 40 ft below surface) underlaid by 4 sand aquifers at 200-,400-,700- and 1,200-ft depths.

II. Landfill operation and effects

A. Operation

1. Area - 900± acres total.
2. Time in operation - NA.
3. Amount/type of material - 200,000 tons, 40 to 50 acres/yr MSW and sludge.

B. Effects

1. Leachate
   Direct drainage into marshlands results in odor and color.
2. Water quality monitoring - NA.
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

C. Other comments

About 100 acres were yet uncovered in 1978. Considerable correspondence with State officials shows some progress has been made toward alleviating open dump conditions, but the site is not yet a sanitary landfill.

Site: Kenner Landfill, City of Kenner, Louisiana--

I. Site characteristics

A. Location

North side of U.S. Highway 61, T-12-S, R-9-E, St. Charles Parish.

B. Hydrology

Tidal wetland.

C. Geology
   Organic clays underlaid by sand aquifers at 200, 400, 700, and 1,200 ft.

II. Landfill operation and effects
   A. Operation
      1. Area - 0.05 acres/day.
      2. Time - NA.
      3. Amount/type of material - MSW.
   B. Effects
      1. Leachate - NA.
      2. Water quality monitoring - NA.
      3. Bioassays - NA.
      4. Available heavy metals - NA.
      5. Total heavy metals - NA.
      6. Methane - NA.

   C. Other comments
      Proposed landfill

Site: Waste Lands, Inc., Louisiana--

I. Site characteristics
   A. Location
      U.S. Highway 61, 1¼ miles past Alamedia Road, St. Charles Parish.
   B. Hydrology
      Tidal wetland.
   C. Geology
      Organic clays underlaid by sand aquifers at 200, 400, 700 and 1,200 ft.

II. Landfill operation and effects
   A. Operation
      1. Area - NA.
      2. Time - NA.
      3. Amount/type of material - 12± acres currently being filled to 4 to 6 ft mean sea level (220,000 cubic yd) since 1972. 500 to 700 yds.^{3}/day of mixed refuse.
   B. Effects
      1. Leachate - NA.
      2. Water quality monitoring - NA.
      3. Bioassays - NA.
      4. Available heavy metals - NA.
      5. Total heavy metals - NA.
      6. Methane - NA.
   C. Other comments
      Edges and top unsealed.

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Maryland

Site: Mullins Sanitary Landfill, Maryland--

I. Site characteristics

A. Location

Five miles east of Aberdeen, south of Route 40 and Penn Central Railroad Tracks.

B. Hydrology

Swan Creek to north, south, and west. Creek changes from tidal to nontidal along the curving part to the west of the landfill.

C. Geology

1. Area is characteristic of Type IV Maryland terrain. Dissected to flat upland area underlaid by coastal plain sedimentary deposits. Well drained except valley bottoms of major streams, which are commonly swampy and filled with alluvium. Water tables here are a few feet below land surface. Hilltop water tables are several tens of feet below the surface.

2. Specific area under this landfill is characterized by well drained, slightly dissected coastal plain deposits, 20 to 40 ft of brown sand and gravel, brown and gray silty clay, and clayey sand.

II. Landfill operation and effects

A. Operation - sanitary landfill.
  1. Area - 2 cells.
  2. Time in operation - Only 6 months at time of water quality monitoring.
  3. Amount/type of material - Average of 150 tons of municipal solid waste per day from 1969 through 1977.

B. Effects
  1. Leachate
     March 1970 - no evidence of leachate.
     August 1970 - 1st cell complete, 4 to 5 ft deep trench filled with leachate, but no chemical analysis done.
  2. Water quality monitoring
     a. Station #1 - approximately 500 yds northwest of landfill on Swan Creek; chosen since leachate might be found there.
     b. Station #2 - Two miles upstream, north of landfill.
     c. Conclusions:
        1. High pH on April 28 caused by company dumping into stream.
        2. Data showed no significant difference in total hardness, chloride, dissolved oxygen, and specific conductivity.

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            3. Neither chemical nor bacterial data showed leachate causing measurable degradation.
            4. It is likely, however, that leachate could mix and never be detected, since the average flow of the river is 7 cfs, which amounts to about 4.5 million gal/day. Therefore, if the landfill contributed as much as 10,000 gallons of leachate/day and mixing occurred before sampling, it would be diluted by a factor of 450/1.
        3. Bioassays - NA.
        4. Available heavy metals NA.
        5. Total heavy metals - NA.
        6. Methane - NA.

Site: Norris Farms, Sanitary Landfill, Maryland--

I. Site characteristics
    A. Location
        1. North Point Road - Maryland Grid-940/520,530.
        2. West of Back River, south of Bread and Cheese Creek, north of the Penn Central Railroad, and west of Rosebank Avenue in Baltimore County, Maryland.
    B. Hydrology
        1. The nearest water is the Back River; Class I to the northeast and Bread and Cheese Creek to the northwest.
    C. Geology
        1. Underlying the site are pleistocene deposits of clays, silts, sands and gravels, varying in depth from 15 to 30 ft.
        2. Under this lies the Patapsco formation consisting of clay lenses and water-bearing sands with blue, grey, and brown clays over this.

II. Landfill operation and effects
    A. Operation - sanitary landfill
        1. Area - 136 acres.
        2. Time in operation - 11 yr
        3. Amount/type of material-1,300 tons/day of residential, commercial, and industrial waste.
    B. Effects
        1. Leachate
           Results of the 7/76 Investigation showed a small leachate seep flowing into a sediment control pond and then into the Back River by way of a marsh.
        2. Water quality monitoring
            a. See Table C-3.
            b. Water quality monitoring of selected wells by the Environmental Health Administration from 1975-79 and sampling sites have shown that certain parameters (sodium, chlorides, dissolved solids) have increased.

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TABLE C-3. WATER QUALITY MONITORING AT TWO STATIONS IN SWAN CREEK, MARYLAND

	Chemical & physical characteristics							Bacterial characteristics	
Date	Measured discharge cfs	Calcium carbonate (total hardness) mg/1	Chloride mg/1	Dissolved oxygen mg/1	Specific Conduc. at 25^oC (μmhos)	pH	Temp. (^oC)	Coliform colonies/ml	Fecal colonies/ml
Station#1									
3/19/70	---	25	---	13.2	230	8.4	4.0	3,200	120
4/28/70	---	80	---	---	130	8.9	15	800	40
5/26/70	6.6	45	---	7.8	140	7.0	19	2,200	400
6/17/70	16.0	45	15	8.2	140	6.7	19	8,200	3,200
7/8/70	---	55	15	9.0	140	7.1	22	4,000	300
8/10/70	4.7	45	12	9.4	110	7.6	21	4,200	1,200
9/22/70	1.81	55	20	8.6	160	7.5	21	1,300	68
Station2									
3/19/70	---	25	---	12.7	240	8.3	4.5	3,900	84
4/28/70	---	80	---	---	130	89	16	2,600	190
5/26/70	---	45	---	8.0	140	7.3	19.5	3,800	620
6/17/70	---	---	17	8.7	160	6.9	20	7,800	3,400
7/8/70	---	55	15	9.3	140	7.6	22.5	---	---
8/10/70	---	45	15	9.9	100	8.2	23	7,800	2,500
9/22/70	---	45	17	9.4	182	80	22	3,600	150

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These particular sites are downgradient from the oldest part of the landfill. (Observation well #1 on Bread and Cheese Creek and Observation Well #2 on Back River.)

3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

SITE: Pennington Avenue, Baltimore, Maryland--

I. Site characteristics

- A. Location
    1. Located west of Pennington Avenue and north of Cabin Branch in Baltimore, Maryland.
    2. Maryland Grid - 915/505.
- B. Hydrology
    1. Nearest surface water is Curtis Bay - Class I waters.
    2. Adjacent stream enters property and forms a large pond about 50 x 100 yd in size. The stream then exits at lower end of site.
    3. Portion of site north of natural drainage swale slopes toward stream. The site south of natural drainage swale slopes toward Pennington Avenue and Cabin Branch.
    4. Groundwater flows southeasterly and easterly toward the Curtis Bay well field.
- C. Geology
    1. Pennington Avenue site is located on the Atlantic Coastal Plain. The tract is underlaid by the Patapsco Formation which consists of irregularly shaped beds of sand, gravel, sandy clay, and clay.

II. Landfill operation and effects

- A. Operation
    1. Area - 68 acres.
    2. Time in operation - approximately 3 yr.
    3. Amount/type of material - 750 to 1,300 tons/day of residential/commercial waste, depending on pyrolysis operation.
- B. Effects
    1. Leachate
        - a. 1977 - No evidence of discharges or runoff from landfill operation was observed.
    2. Water quality monitoring
        - a. Only data available were from surrounding wells; however, location of wells was unavailable.
        - b. 1977 - The specific conductivity upstream of pond was 1,500 μmhos; downstream, it was 165 μmhos.

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3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

Site: Quarantine Road - Sanitary Landfill, Maryland--

I. Site characteristics
  A. Location
    1. Southeast corner of Baltimore City.
    2. Bounded by Baltimore and Ohio Railway on northeast and the Francis Scott Key Bridge approach of Interstate 695 on the south.
    3. Maryland Grid: - 920/500.
  B. Hydrology
    1. Runoff from the site eventually flows into Thomas Creek, which empties into Thomas Cove and the Patapsco River.
    2. Groundwater - a perched water table, locally 88 ft above sea level. The true groundwater surface in some areas varies from several ft above to several ft below sea level.
  C. Geology
    1. Topography of the site - results from excavation, fill and uncontrolled disposal that have occurred. Highest elevation = 111 ft, from which it slopes eastward to 30 to 35 ft above sea level.
    2. Soil
      a. Clay facies (1.5 to 165 ft thick); buff, red-yellow, and brown kaolinitic clays. Some sand and silt.
      b. Sand facies - well sorted, medium to fine-grained quartz.
      c. A clay layer bounds the site except to the south and southwest.

II. Landfill operation and effects
  A. Operation
    1. Area - 86 acres.
    2. Time in operation - Solid waste disposal has been conducted for 10 yr.
       Industrial Waste has been disposed of for an unknown time before this. Industrial acids and chemical waste were once disposed into ponded water.
    3. Amount/type of material
      a. 600 tons/day of MSW and industrial hazardous waste.
      b. Estimated total fill for life of site (including past disposal) is approximately 7.6 million yd^3, which amounts to 3.0 million solid waste tons (based on in-place solid waste density of 1,000 lb/yd^3).
  B. Effects
    1. Leachate

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a. Results of 7/76 inspection showed an area of discolored ponded water with a strong odor. Runoff from ponds eventually flows through a 36 in. diameter pipe into a marshland, which is now devoid of vegetation. The effluent then migrates to Baltimore's outer harbor.

2. Water quality monitoring
   a. See Table C-4.
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

New Jersey

Site: Avon Landfill, Town of Lyndhurst, New Jersey--

I. Site characteristics
   A. Location
      Adjacent to Erie-Lackawanna railroad line, north side.
   B. Hydrology
      Observed groundwater level varied through site from less than 3 ft to 8 ft mean sea level. Freshwater marsh.
   C. Geology

+3 ft to -12 ft mean sea level	organic silt and peat
-5 ft to -125 ft mean sea level	gray-varved silty clay
-26ft to -62 ft mean sea level	red-brown coarse to fine sand, little silt and clay, little medium to fine gravel
-62 ft to -68 ft mean sea level	red shale bedrock

II. Landfill operation and effects
   A. Operation
      1. Area - 550 ft x 7,700 ft
      2. Time in operation - since 1955. Projected closing date is 6/30/78. Site must be closed by the end of 1979, according to the Hackensack Meadowlands District Commission.
      3. Amount/type of material - Estimated amount of solid waste received between 3/29/77 and 4/12/78 is 160,000 tons. Estimated in-place compaction achieved is 1,100 lb/yd^3.
   B. Effects
      1. Leachate - NA.
      2. Water quality monitoring - NA.
      3. Bioassays - NA.
      4. Available heavy metals - NA.
      5. Total heavy metals - NA.
      6. Methane - NA.

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TABLE C-4. LABORATORY AND FIELD WATER QUALITY ANALYSIS FROM A 7/76 SANITARY LANDFILL INSPECTION BY THE MARYLAND WATER RESOURCES ADMINISTRATION

	Sampling site*					
Variables	Marsh Site Within Landfill	Marsh Site Closest To River	Sediment Pond On East Side Of Landfill	Pond Within Landfill	Springs Outside Of Northeast Landfill Boundry	Spring Within Landfill
Field Ph	7.5	6.8	9.4	2.4	5.3	4.4
Field temperature	24°C	25°C	25°C	34°C	25°C	26°C
Laboratory pH	7.1	7.1	9.4	2.7	4.5	4.5
Biological oxygen demand	57.6	16.8	6.0	66.2	48.0	28.8
Chemical oxygen demand	232.0	84.0	144.0	21.3	6,384.0	17.02
Sulfate	164.0	54.0	106.0	1,250.0	34,722.0	200.0
Chloride	193.5	107.5	--	490.0	415.0	11.5
Ammonia	1.20	0.78	0.27	1.03	39.71	0.01
Nitrate	0.01	0.83	0.01	<0.01	0.01	0.96
Total hardness	460.0	508.0	212.0	970.0	520.0	93.0
Mercury	0.0020	0.0043	0.0007	0.0004	0.0025	0.0009
Nitrite	0.010	0.420	0.200	0.020	0.008	0.003
Total iron	0.18	0.95	--	850.00	5,560.00	0.20
Total chromium	<0.10	<0.10	<0.10	1.22	1.90	<0.10
Zinc	--	<0.05	0.03	6.50	2.00	0.19
Lead	<0.50	<0.50	<0.50	0.50	1.20	1.80
Cadmium	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic	<1.0	<1.0	<1.0	3.7	4.0	<1.0
Selenium	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dissolved solids	1,128.0	2,456.0	920.0	7,582.0	26,900.0	290.0
Volatile solids	216.0	88.0	172.0	1,600.0	3,832.0	36.1
Alkalinity	268.1	58.4	260.0	0.0	0.0	0.0

*Units are mg/l unless otherwise indicated.

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Site: Bergen County Landfill, Lyndhurst, New Jersey--

I. Site characteristics

A. Location

Adjacent to Erie-Lackawanna railroad line, south side.

B. Hydrology

Freshwater marsh area (Atlantic Flyway).

Average daily tides: 3 ft at high tide and less than 2.2 ft at low tide.

Storm high tides:

1 yr storm	5.5 ft
2 yr storm	6.5 ft
5 yr storm	7.0 ft
10 yr storm	7.5 ft
50 yr storm	8.0 ft
100 yr storm	8.6 ft

A 2,100 million gal/tide cycle (30.4%) enters Sawmill Marsh East, which affects the landfill.

C. Geology

0 ft to -20 ft msl -meadow material, organic silt, gray-brown fine silty-sand, and red-brown silt, gray-soft varved silt

-20 ft to -110 ft msl -red-brown silty clay with layers of fine sand

II. Landfill operation and effects

A. Operation

1. Area - 200 acres, 70 ft high.
2. Time in operation - Closing date has been extended from the end of 1979 until 1982.
3. Amount/type of material -

B. Effects

1. Leachate - See Table C-5.
   Sample at Tide Gate Station taken before Hackensack Meadowlands District Commission tightened standards:
   Low BOD - typical of leachate
   High in particulates
   High in surfactants
   Leachate is leaking into the marsh from the diked landfill, but the marsh is in visibly excellent condition and seems to be insensitive to leachate to date.
2. Water quality monitoring - See Table C-5.
3. Bioassays - NA.
4. Available heavy metals (lb/acre), March 1974:

Fe	Mn	Cu	Zn	Ni	Cr	Cd	Pb
93.8	17.4	0.82	0.80	0.88	0.36	0.30	0.24

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TABLE C-5. BERGEN COUNTY LANDFILL WATER QUALITY ANALYSIS

		Sampling site		
	HMDC	#1	#2	#3
Biological oxygen demand	25 mg/l	8	8	--
Chemical oxygen demand	^{1}50 mg/l	180	120	250
pH	6.5 - 8.5	8.0	7.85	7.60
Turbidity	40 Jtµ	55	28	165
Color	40 SU	630	350	--
Temperature	85°F	--	--	--
Nitrogen	30 mg/l	--	--	28
Suspended solids	40 mg/l	14	7	180
Phosphates	30 mg/l	--	--	--
Phenols	0.2 mg/l	--	--	--
Coliform, total	5,000/100ml	--	--	10,700/100ml
Coliform, fecal	1,500/100ml	--	--	--
Acidity	^{4}N/A	45	40	--
Chlorides	^{3}N/A	2,110	1,460	1,760
Copper	^{2}0.24 mg/l	--	--	0.15
Hardness	N/A	1,090	785	--
Iron	N/A	0.75	0.25	--
Sulfite	^{5}165 mg/l	485	336	--
	^{6}50 mg/l	10	--	--
Surfactants	^{7}2.0 mg/l (as ABS)	370	220	--
Total solids	N/A	4,630	3,170	4,030
Volatile solids	N/A	600	498	510
Dissolved solids	^{8}2,000 mg/l	4,620	3,160	3,850
Settled solids	N/A	0.1 ml/l	--	0.3 ml/l

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5. Total heavy metals (lb/acre), March 1974

Fe	Mn	Cu	Zn	Ni	Cr	Cd	Pb
60,000	680	440	1,800	240	1,000	10	480

C. Design

Dike extends into the clay layer, with a top width of 10 ft, a maximum side slope of 2:1, and an elevation of 10 ft.

Site: Municipal Sanitary Landfill Authority, Landfill Site #I-C, Kearney, New Jersey--

I. Site characteristics

A. Location

Southwestern boundary abuts the Belleville Turnpike.

B. Hydrology

Area of shallow tidal bays and mud flats occupies 500 acres in the adjacent Sawmill Creek area. Inundated with water during every high tide. Has highest salinity level (5-15 ppt) of 5 biozones of the Hackensack estuary. Forty percent of the tide enters here.

C. Geology

The Hackensack Meadowlands area lies on top of what was once the bottom of Glacial Lake Hackensack. Layers of peat and organic soils underlie the marsh/estuary, where salt and fresh water mix. II. Landfill operation and effects

A. Operation

Modified area method of compaction of solid waste material into cellular refuse structures.

1. Area - 75 ft elevation over 3/4 of area (12/78).
2. Time in operation - NA.
3. Amount/type of material - 3,954, 537 yd^3 (1,384,087 tons) of solid waste deposited between 12/1/77 and 12/1/78. Approximately 60% to 75% municipal and household solid waste
   - 5% to 8% product of demolition work
   - 15% to 20% solid commercial and industrial waste
   - 5% to 8% unclassified miscellaneous loads

B. Effects

1. Leachate - NA.
2. Water quality monitoring (see Table C-6).
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - No effect seen after 10 yr of monitoring.
6. Methane - No sampling data.

TABLE C-6. WATER QUALITY MONITORING
MUNICIPAL SANITARY LANDFILL AUTHORITY, LANDFILL SITE #I-C, KEARNY, NEW JERSEY

	Range of values in four sampling sites*			
Variable	6/78	9/78	12/78	3/79
Lead†	0.06	0.06	0.05	0.04
Zinc†	0.15	<0.10	0.93	0.10
Magnesium†	0.002	--	--	--
Chromium†	0.08	0.10	0.55	<0.05
Phenol†	0.004	0.006	<0.002	0.002
Total suspended solids	28-86	45-130	122-128	20-40
pH	7.1-7.2	7.2-7.6	7.2-7.3	6.7-7.3
Color (CU)	100†	112-138	100†	100†
Turbidity (JTU)	50†	116-554	25†	20†
Total nitrogen	55-70	32-65	16-24	3.9-13.6
Total phosphorous	3.6†	--	0.2†	1.0†
Oil and grease	0.16†	0.15†	0.12†	<0.1†
Salinity	1,500-2,175	9,650-11,520	5,932-10,020	656-1,383
Biological oxygen demand	0.4-4.2	0.9-3.4	0.5-4.6	0.25-0.8
Chemical oxygen demand	60-147	75-135	18-175	25-68
Total coliform MPN index/100 ml				
Mercury	--	0.009†	<0.002†	<0.002†

* ppm unless otherwise indicated.
† Sampled at one site only.

TABLE C-7. WATER QUALITY MONITORING OF MUNICAPAL SANITARY LANDFILL AUTHORITY LANDFILL SITE #1-A, KEARNEY, NEW JERSEY

Variable	Date of sampling in fill sites*					
	12/20/77	5/3/78	6/16/78	9/20/78	12/26/78	3/28/79
Lead	<0.05	0.10	0.09	0.09	0.02	0.04
Zinc	<0.005	<0.005	1.0†	0.1	0.14	0.12
Magnesium	--	--	0.003	--	--	--
Chromium	<0.05	<0.02	0.16	0.18	0.04	<0.05
Phenol	0.003	0.008	0.005	0.01	<0.002	0.006
Total suspended solids	56	70	40	65	10	6
pH	7.4	6.7	7.2	7.6	7.4	6.8
Color (CU)	10	7	120	195	380	180
Turbidity (JTU)	10	0.1	45	138	180	38
Total nitrogen	21	3.9	76	25	25	4.6
Total phosphorous	0.1	<0.02	0.6	--	0.05	0.1
Oil and grease	14	8	0.15	0.18	0.14	<0.1
Salinity (ppt)	28	12.7	12.9	9.9	7.3	4.33
Dissolved oxygen	1.7	0.2	0.4	4.2	0.4	1.0
Biological oxtgen demand	5	24	33	230	45	22
Total Coliform MPN index/100ml	<2,400	--	20	7	28	3
Mercury	--	<0.0002	--	0.006	<0.002	<0.002
No. of violations	3	2	7	6	5	3

---

* ppm unless otherwise indicated.

† Circled figures indicate violations.

Total number of violations of standards = 26.

Site: Municipal Sanitary Landfill Authority, Landfill Site #1-A, Kearny, New Jersey--

I. Site characteristics
  A. Location
  B. Hydrology
     Area of shallow tidal bays and mudflats occupies 500 acres in the nearby Sawmill Creek area, and is inundated with water during every high tide. This area has the highest salinity level (5 to 15 ppt) of the 5 biozones of the Hackensack estuary.
  C. Geology
     The present Hackensack Meadowlands area lies on top of what was once the bottom of Glacial Lake Hackensack. Layers of peat and organic soils underlie the marsh/estuary, where salt and freshwater mix.

II. Landfill operation and effects.
  A. Operation
     1. Area - NA.
     2. Time - NA.
     3. Amount/type of material - presently inactive, no solid waste deposited in 1978.
  B. Effects
     1. Leachate
     2. Water quality monitoring (see Table C-7).
     3. Bioassays - NA.
     4. Available heavy metals - NA.
     5. Total heavy metals - NA.
     6. Methane -
        3/78 - 0.1%
        5/78 - 0%
        6/78 - 3.5%
        7/78 - 4%
        8/78 - 4%
        9/78 - 4%
        10/78 - 4%
        11/78 - 3.2%
        12/78 - 4%

Site: Municipal Sanitary Landfill Authority, Landfill Site #I-D, Kearny, New Jersey--

I. Site characteristics
  A. Location
  B. Hydrology
     Area of shallow tidal bays and mudflats occupies 500 acres in the nearby Sawmill Creek area and is inundated with water during every high tide. This area has the highest salinity level (5-15 ppt) of the five biozones of the Hackensack estuary.

C. Geology

The Hackensack Meadowlands area lies on top of what was once the bottom of Glacial Lake Hackensack. Layers of peat and organic soils underlie the marsh/estuary, where salt and freshwater mix.

II. Landfill operation and effects

A. Operation

Modified area method of compaction into cellular refuse structures

1. Area - 76 ft overall elevation (12/78).
2. Time in operation - NA.
3. Amount/type of material - 1,587,334 yd^3 (555,566 tons) of solid waste deposited between 12/1/77 and 12/1/78.

Approximately 60% to 75% municipal and household solid waste.
5% to 8% product of demolition work.
15% to 20% solid commercial and industrial waste.
5% to 8% unclassified.

B. Effects

1. Leachate - NA.
2. Water quality monitoring - see Table C-8.
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane

3/78	0.1 and 2.5%
5/78	3.1%
6/78	4.0%
7/78	2.2%
8/78	1.9%
9/78	2.2%
10/78	2.8%
11/78	.8%
12/78	2.7%

New York

Site: Babylon Landfill, Long Island, New York--

I. Site characteristics

A. Location

Suffolk Co., Long Island.

B. Hydrology

Groundwater reservoir recharge occurs from precipitation and by infiltration of precipitation to the water table. Approximately half of the annual precipitation of 47 in. infiltrates.

Regional groundwater flow is parallel to the water table and along the hydraulic gradient, which is in a southerly direction

TABLE C-8. WATER QUALITY MONITORING OF MUNICIPAL SANITARY LANDFILL AUTHORITY, LANDFILL SITE #I-D, KEARNY, NEW JERSEY

Variable	Date of sampling			
	6/78	9/78	12/78	3/79
Lead	0.05	0.10	0.04	<0.02
Zinc	0.20	0.3	0.32	0.22
Magnesium	0.002	--	--	--
Chromium	0.12	0.15	0.12	<0.05
Phenol	0.020	0.060	0.008	0.004
Total suspended solids	840	770	6,538	30
pH	7.5	7.4	7.4	7.1
Color (CU)	400	430	black	320
Turbidity	650	765	<1,000	46
Total nitrogen	125	89	41	2.6
Total phosphorous	3.8	--	0.4	0.1
Oil and grease	0.75	1.65	0.22	<0.1
Salinity	1,120	2,760	2,006	609
Dissolved oxygen	0.4	4.4	0.6	0.3
Biological oxygen demand	165	160	89	5
Total coliform MPN index/100 ml	--	--	--	93 (15-320)
Mercury	--	0.010	<0.002	0.002

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toward stream discharge areas and the Great South Bay.

Most of the groundwater flowing under the landfill remains in the upper glacial aquifer, with little penetrating the Gardiners Clay. A plume of leachate contaminated groundwater extends 10,600 ft from the landfill deposition site and sinks to the bottom of the 71 ft to 79 ft deep upper glacial aquifer.

C. Geology

The upper glacial aquifer, which is composed of saturated outwash deposits of medium to coarse sand with some gravel, varies in depth from 71 ft to 79 ft, and has an estimated hydraulic conductivity of 130 - 400 ft/day. This overlies the Gardiners Clay, which varies in thickness from 10 ft to 12 ft, and has a downward head differential of 3 ft. The Gardiners Clay essentially acts as a barrier to downward migration of water from the upper glacial aquifer.

The landfill is situated on an outwash plain which slopes toward Great South Bay, which is 4.6 miles away. It is 60 ft above sea level, and 15 ft above the groundwater table.

II. Landfill operation and effects

A. Operation

Solid waste disposal was by incineration from 1947 to 1975; direct dumping to the landfill occurs during overloads and breakdowns. Scavenger waste has been deposited since 1966.

1. Area - 1,650 x 2,260 ft, with three refuse piles covering an area of 25 acres (1973).
2. Time in operation - 1947 to present.
3. Amount/type of material - Average amounts between 1968 and 1972 were 368 tons/day incinerated rubbish and 602 yd^3/day demolition waste, compostables, and noncombustibles. 40,000 gal/day - scavenger waste.

B. Effects

1. Leachate
   A leachate contaminated plume of groundwater extends 10,600 ft downgradient from the landfill site and extends to the bottom of the upper glacial aquifer. There is no significant lateral spread of leachate.
2. Water quality monitoring - (See Table C-9).
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

Site: Islip Landfill, Long Island, New York--

I. Site characteristics

A. Location

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TABLE C-9. WATER QUALITY ANALYSIS OF BABYLON LANDFILL, SUFFOLK COUNTY, LONG ISLAND, NEW YORK *

Variable	Amount
Lead	---
Zinc	220 μg/1
Magnesium	---
Chromium	---
Phenol	---
Total suspended solids	---
pH	7
Color (CU)	---
Turbidity	---
Total nitrogen	> In plumes than in ambient H_2O - a minor component
Total phosphorous	---
Oil and grease	---
Salinity	---
Dissolved oxygen	---
Biological oxygen demand	---
Total coliform MPN index/100ml	---
Bicarbonate	>50 mg/1 - concentration significantly < in plume than in ambient H_2O.
Iron	200,000-400,000 μg/1†, especially enriched in plume
Manganese	200,000-400,000 μg/1†, especially enriched in plume
NH_4+Ammonium	Usually >10% of 90 mg/1 max.
NO_3-Nitrite	<Concentrations of ambient H_2O
C1- Cloride	Concentration significantly > in plume than in ambient H_2O
$SO_4{}^{-2}$ Sulfite	Concentration significantly > in plume than in ambient H_2O

* Data extracted from G. E. Kimmel and A. C. Braids, Preliminary Findings of a Leachate Study on Two Landfills in Suffolk County, New York. 1975.

† Extracted from text. Samples taken from observation wells installed by U. S. Geological Survey.

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Suffolk Co., Long Island.

B. Hydrology

Groundwater reservoir recharge occurs from precipitation and by infiltration of precipitation to the water table. Approximately half of the annual precipitation of 43 in. infiltrates.

Regional groundwater flow is parallel to the water table and along the hydraulic gradient, which is in a southerly direction towards stream discharge areas and the Great South Bay.

Most of the groundwater flowing under the landfill remains in the upper glacial aquifer, with little penetrating the underlying beds of silty fine sand. A plume of leachate contaminated groundwater extends 5,000 ft from the landfill deposition site, and sinks to the bottom of the 170 ft deep upper glacial aquifer.

C. Geology

The upper glacial aquifer, which is composed of saturated outwash deposits of medium to coarse sand with some gravel, extends to a depth of 170 ft below the water table and has an estimated hydraulic conductivity of 270 ft per day. Underlying this aquifer are beds of silty fine sand that probably form the hydrologic boundary that retards the downward flow of groundwater and thereby prevents contamination of underlying groundwater. The landfill is situated on an outwash plain that slopes toward Great South Bay, which is 3.9 miles away. It is 60 ft above sea level, and 20 ft above the groundwater table.

II. Landfill

A. Operation

1. Area - 17 acres of refuse, with a maximum thickness of 46 ft (1973).
2. Time - 1933 to present.
3. Amount/type of material - average amounts between 1970 and 1972:
    151 tons/day of incinerated rubbish
    6,200 tons/day of demolition and noncombustible waste
   Total (1973): 8.3 x 10^5 yd^3 of material.

B. Effects

1. Leachate (See Table C-10).
   A leachate contaminated plume of groundwater extends 5,000 ft downgradient from the landfill site and extends vertically to the base of the 170 ft thick upper glacial aquifer. The highest dissolved solids concentration is generally near the bottom of the plume. There is no significant lateral spread of leachate.
2. Water quality monitoring (See Table C-10).
3. Bioassays - NA.

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TABLE C-10. CHEMICAL ANALYSES OF LEACHATE-ENRICHED GROUNDWATER IN STUDY AREAS*

Constituents and characteristics	Babylon Landfill†	Islip Landfill∫
Major constituents (mg/1):		
Silica (Si_2)	<1-8.9	7.1-11
Calcium (Ca)	0-100	0-20
Magnesium (Mg)	5.5-53	6.2-55
Sodium (Na)	43-700	39-260
Potassium (K)	5.3-110	1.1-75
Bicarbonate (HCO_3)	54-898	31-1,010
Carbonate (CO_3)	0	0
Akalinity as $CaCO_3$	44-737	25-828
Sulfate (SO_4)	19-100	26-150
Chloride (C1)	55-910	29-400
Fluride (F)	0-0.1	0-0.4
Bromide (Br)	0.15-4.2	0.36-2.3
Nitrate (NO_3)	0.05-2.7	0.34-1.1
Nitrite (NO_2)	0	0.17
Nitrogen, ammonia as N	5.3-43	0-14
Minor constituents (μg/L):		
Arsenic (As)	0-14	2-29
Boron (B)	300-2,500	240-1,200
Copper (cu)	0-20	0
Lead (Pb)	0-1	0-6
Selenium (Se)	1-2	0-2
Strontium (Sr)	160-1,400	130-370
Zinc (Zn)	10-80	10-190
Aluminum (Al)	0-50	0-20
Iron (Fe)	180-24,000	100-39,000
Manganese (Mn)	10-5,400	20-1,900

(continued)

See footnotes at end of table.

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TABLE C-10 (continued).

Constituents and characteristics	Babylon Landfill†	Islip Landfill∫
Other characteristics:		
Disolved solids	219-2,300	223-1,560
Residue at 180°C (mg/1)	230-2,475	196-1,548
Calculated (mg/1)	65-450	60-676
Hardness as $CaCO_3$ (mg/1)	0-220	0-35
Noncarbonate hardness (mg/1)	450-4,400	340-2,750
Specific conductance	5.6-7.1	5.5-6.5
(μmho/cm at 25°C)		
pH		

* Information from U. S. Geological Survey open file report 77-583, Leachate Plumes in Groundwater from Babylon and Islip Landfills, Long Island, New York, 1977.

† Range of lab results- from five test wells.

∫ Range of lab results from four test wells.

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Site: North Hempstead Landfill, North Hempstead, Long Island--

I. Site characteristics

A. Location

In sand pit area on the east side of Port Washington Peninsula. Two parcels receive waste: one of these (lot 1033) is located 2,000 ft west of Roslyn West Shore Drive against the sand banks exposed during past mining operations, and the other (lot 1034) is contiguous and fronts on Roslyn West Shore Drive. Two additional parcels are located between Roslyn West Shore Drive and Hempstead Harbor.

B. Hydrology

The groundwater table is 15 to 20 ft below the bottom of the lower areas of the landfill, at approximately 16 to 20 ft. msl. The groundwater is highest along the axis running north and south and through the center of the peninsula. Direction of flow is northerly and from the central axis to the west and to the east. There is a net outflow of groundwater from the peninsula to Hempstead Harbor.

C. Geology

Clay lenses exist between the landfill surface and the monitoring well screens. Liquid entering the ground at the landfill surface would probably have greater lateral than vertical movement and not enter the lower groundwater levels at the landfill site. Borings indicate that no significant confining layers exist to prevent ultimate seepage of the leachate to the upper groundwater.

II. Landfill operation and effects

A. Operation

1. Area - NA.
2. Time in operation - NA.
3. Amount/type of material - Residential, commercial, industrial solid waste, and sewage treatment plant sludge.

B. Effects

1. Leachate. See Tables C-11 and C-12.
2. Water quality monitoring

   Four monitoring wells and one general purpose well are installed at the site. Landfill has not caused any degradation to the District well water supply system, but poses a serious threat for the future.
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

South Carolina

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Site: North Hempstead Landfill, North Hempstead, Long Island--

I. Site characteristics

A. Location

In sand pit area on the east side of Port Washington Peninsula. Two parcels receive waste: one of these (lot 1033) is located 2,000 ft west of Roslyn West Shore Drive against the sand banks exposed during past mining operations, and the other (lot 1034) is contiguous and fronts on Roslyn West Shore Drive. Two additional parcels are located between Roslyn West Shore Drive and Hempstead Harbor.

B. Hydrology

The groundwater table is 15 to 20 ft below the bottom of the lower areas of the landfill, at approximately 16 to 20 ft msl. The groundwater is highest along the axis running north and south and through the center of the peninsula. Direction of flow is northerly and from the central axis to the west and to the east. There is a net outflow of groundwater from the peninsula to Hempstead Harbor.

C. Geology

Clay lenses exist between the landfill surface and the monitoring well screens. Liquid entering the ground at the landfill surface would probably have greater lateral than vertical movement and would not enter the lower groundwater levels at the landfill site. Borings indicate that no significant confining layers exist to prevent ultimate seepage of the leachate to the upper groundwater.

II. Landfill operation and effects

A. Operation

1. Area - NA.
2. Time in operation - NA.
3. Amount/type of material - Residential, commercial, industrial solid waste, and sewage treatment plant sludge.

B. Effects

1. Leachate. See Tables C-11 and C-12.
2. Water quality monitoring

   Four monitoring wells and one general purpose well are installed at the site. Landfill has not caused any degradation to the District well water supply system, but poses a serious threat for the future.
3. Bioassays - NA.
4. Available heavy metals - NA.
5. Total heavy metals - NA.
6. Methane - NA.

TABLE C-11. LEACHATE ANALYSIS OF NORTH HEMPSTEAD LANDFILL, NORTH HEMPSTEAD, LONG ISLAND*†

Constituent	(manhole) 3/75	(pond) 3/75	9/75	5/76
Total hardness	1,260	1,640	4,400	5,200
Calcium	300	336	--	992
Alkalinity (M.O.)	580	740	3,100	4,400
Chloride	680	750	5,000	2,120
Sulfate	382	336	--	347
Nitrate-nitrogen	1.13	0.35	2.90	<0.02
Nitrite-nitrogen	<0.005†	<0.005†	--	0.26
Conducitivity	--	--	--	--
Total dissolved solids	54	5,329	16,600	17,800
pH	5.8	6.2	6.7	6.4
Iron (total)	130.0	88.0	430.0	595.0
Copper	0.24	0.07	--	0.12
Zinc	16.0	4.9	8.75	17.0
Cadmium	--	--	--	--
Lead	0.04	<0.02†	--	<0.02†
Manganese	9.4	15.0	--	--
Sodium	440	560	--	1,400
Color	35	50	300	400
Chromium (Hex)	<0.01†	<0.01†	--	0.148
Coliforms (MPH/100 ml)	430	2,400	<3.0†	240
Fecal coliforms (MPN/100 ml)	<3.0†	<3.0†	--	<3.0†
Solids	54	--	16,600	--
Chemical oxygen demand (COD)	5,837	6,144	18,574	19,100
Ammonia	174.2	128.8	--	536.0
Total kieldahl nitrogen	--	137.5	--	599.0
Surfactants (MBAS)	0.33	0.45	--	0.07
Phosphates (total)	0.13	0.10	--	0.075
Phosphates (ortho)	0.13	0.10	--	--
Chromium (total)	<0.01†	0.03	--	0.10
Mercury (Hg)	0.001	0.029	--	<0.0005†
Phenol	--	--	--	1.2
Beryllium	0.003	0.003	--	n.d.
Turbidity	525	680	940	96
Arsenic	<0.003†	<0.003†	--	0.020

* Samples analysis submitted by Henderson and Casey, Consulting Engineers.
† Units are mg/l unless otherwise noted.

TABLE C-12. NORTH HEMPSTEAD LANDFILL LEACHATE MONITORING PROGRAM

Constituent *		8/78 (manhole)	8/78 (treated with lime)	11/78 (manhole)	11/78 (treated with lime)
Chromium (total)	Cr	--	--	--	--
Chromium (hex)	Cr^{+6}	--	--	--	--
Lead	Pb	--	--	--	--
Mercury	Hb	--	--	--	--
Arsenic	As	--	--	--	--
Beryllium	Be	--	--	--	--
Selenium	Se	--	--	--	--
Boron	B	--	--	--	--
Phenol		--	--	--	--
Ph		6.9	12.1	6.7	11.9
Sulfate	SO_4	--	--	--	--
Phosphate (total)	P	--	--	--	--
Phosphate (ortho)	P	--	--	--	--
Surfactants	MBAS	--	--	--	--
Chemical oxygen demand	COD	4,270	9,710	7,620	8,950
Total organic carbon	TOC	--	--	--	--
Total coliform		--	--	--	--
Fecal coliform		--	--	--	--
Total hardness	$CaCO_3$	--	--	--	--
Akalinity	$CaCo_3$	--	--	--	--

continued

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*See note at bottom of table.

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TABLE C-12 (continued).

Constituent *		8/78 (manhole)	8/78 (treated with lime)	11/78 (manhole)	11/78 (treated with lime)
Conductivity		--	--	--	--
Total Dissolved Solids		18,260	13,200	9,565	11,060
Color	CU	--	--	--	--
Turbidity	JTU	--	--	--	--
Sodium	Na	--	--	--	--
Potassium	K	--	--	--	--
Calcium	Ca	--	--	--	--
Chloride	Cl	2,300	2,000	2,360	2,200
Nitrate	N	0.2	0.04	0.01	0.34
Nitrite	N	0.220	-0.007	0.012	0.008
Ammonia	N	483	420	780	610
Kjeldahl nitrogen	N	700	460	--	--
Iron	Fe	70.2	1.15	200.0	0.60
Manganese	Mn	5.1	-0.05	12.0	-0.05
Copper	Cu	--	--	--	--
Zinc	Zn	9.75	0.27	7.8	0.11

* Units are mg/l unless otherwise noted.

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Site: City of Charleston, South Carolina--

I. Site characteristics
   A. Location
      North of Cooper River Bridge, East of County Jail.
   B. Hydrology
      Tidal marsh.
   C. Geology
      NA.

II. Landfill operation and effects
   A. Operation
      1. Area - 5 acres.
      2. Time in operation - 1 yr.
      3. Amount/type of material - unknown amount MSW.
   B. Effects
      1. Leachate - NA.
      2. Water quality monitoring - NA.
      3. Bioassays - NA.
      4. Available heavy metals - NA.
      5. Total heavy metals - NA.
      6. Methane - NA.

   C. Other comments
      Unauthorized fill halted by regulatory agencies.

Site: Ashley River Dump, City of Charleston, South Carolina--

I. Site characteristics
   A. Location
      East bank Ashley River, north of Ashley River Memorial Bridge.
   B. Hydrology
      Former tidal wetland, now completely filled.
   C. Geology
      NA.

II. Landfill operation and effects
   A. Operation
      1. Area - 190± acres.
      2. Time in operation - 1956-1969.
      3. Amount/type of material - 15 to 20 ft of refuse, about 15.6 x 10^6 yds.^{3} MSW and mixed refuse.
   B. Effects
      1. Leachate - Two drainage ditches discharge leachate to Ashley River.
      2. Water quality monitoring - see Table C-13.
      3. Bioassays - NA.
      4. Available heavy metals - NA.

TABLE C-13. WATER QUALITY ANALYSIS OF ASHLEY RIVER LANDFILL, CHARLESTON, SOUTH CAROLINA

Station	Date (1974)	Time	Tide	Flow (gpm)	BOD (mg/1)	TKN (mg/1)	NH_3-H (mg/1)	NO_3 +NO_2-N (mg/1)	Total Phosphorus (mg/1)	Conductivity (µmhos/cm)
				WATER QUALITY SAMPLES						
C-1	12/12	1300	L			.35	.10	.05*	.05*	23,980
C-2	12/12	1315	L			.25	.09	.05	.03	23,440
C-3	12/12	1325	L			.42	.15	.05	.03	22,890
C-4	12/12	1340	L			.36	.30	.28	.08	26,160
C-5	12/12	1500	L	500†						26,250
C-6	12/12	1515	L	30∫						26,460
C-1	12/13	0840	H		2	.20	.09	.05	.03	23,600
C-2	12/13	0845	H		2	.15	.04	.05	.03	23,175
C-3	12/13	0850	H		2	.30	.04	.05	.03*	23,600
C-4	12/13	0855	H		2	.18	.04	.05	.03	23,640
C-5	12/13	0920	H		4	.25	.09	.05	.03	23,540
C-6	12/13	0925	H		4	.28±10%	.11	.05	.03	23,500

SEDIMENT SAMPLES

	Cr (µg/gm)	Pb (µg/gm)	Fe (µg/gm)	Zn (µg/gm)	Cu (µg/gm)	% Moisture
C-1	33.5	460	23,200	294	42	73
C-2	46 *	76±6%	33,400±2%	185±1%	50*	60
C-3	48	73	38,000	227	68	71
C-4	63	89	38,800	262	82	70

* No difference in duplicate samples.
† Flow determined from pigmy current meter.
∫ Flow estimated.

5. Total heavy metals - NA.
6. Methane - NA.

C. Other comments

Army Corps permit issued after the fact, with conditions. Large areas now developed with additional areas (especially along river and ditches) of uncovered refuse. Results of leachate testing in a drainage ditch that originates offsite and passes through the dump site is in the Table C-14.

Site: Charleston Naval Yard, South Carolina--

I. Site characteristics
  A. Location
    lat. 32°50'N, long. 79°58'W, north of rail yard.
  B. Hydrology
    Former tidal marsh.
  C. Geology
    NA.

II. LANDFILL
  A. Operation
    1. Area - 55±acres
    2. Time in operation - NA.
    3. Amount/type of material - NA.
  B. Effects
    1. Leachate - NA.
    2. Water quality monitoring - NA.
    3. Bioassays - NA.
    4. Available heavy metals - NA.
    5. Total heavy metals - NA.
    6. Methane - NA.

Site: Sullivans Island Township, South Carolina--

I. Site characteristics
  A. Location
    North of Montrieville, bordering Intracoastal Waterway northeast of lat. 32°45'30" N, long. 79°51'W.
  B. Hydrology
    Tidal marsh.
  C. Geology
    NA.

II. Landfill operation and effects
  A. Operation
    1. Area - 53± acres.
    2. Time - Pre - 1972.

TABLE C-14. EPA REGION IV WATER QUALITY TESTING, ASHLEY RIVER DUMP DRAINAGE DITCH, CHARLESTON, SOUTH CAROLINA*

Constituent	Concentration (ppm)†	
	Upstream	Downstream
Total organic carbon	115	648
Zinc	nd∫	3
Cadmium	nd	nd
Argon	nd	nd
Boron	>5	>5
Iron	2.8	>7.5
Molybdenum	0.1	1.8
Aluminum	>10	4.2
Beryllium	<0.1	<0.01
Copper	0.07	0.8
Silver	nd	nd
Nickel	nd	0.5
Lead	nd	nd
Chromium	0.1	0.1
Vanadium	nd	nd
Barium	0.3	0.2
Strontium	0.2	0.6
Fecal coliforms/100 ml	550	1,367
Fecal streptococcus (10^4/100ml)	24	4.7
Biological oxygen demand (5-day)	na	878
Phosphate	8.7	3.1
Sulfates	101	277
Nitrogen	362	317

* Sample locations, timing and results were as follows:

C-1 - Ashley River - 100 ft out from discharge point C-6.
C-2 - Ashley River - 100 ft from east bank equidistance between C-5 and C-6.
C-3 - Ashley River - 100 ft. out from discharge point C-5.
C-4 - Ashley River - approximately ½ mile upstream from fill area.
C-5 - Discharge from drainage ditch on north side of fill area.
C-6 - Discharge from drainage ditch on south side of fill area.

† Average two - three readings.
∫ Not detectable.

        3. Amount/type of material - undetermined amount MSW.
    B. Effects
        1. Leachate - NA.
        2. Water quality monitoring - NA.
        3. Bioassays - NA.
        4. Available heavy metals - NA.
        5. Total heavy metals - NA.
        6. Methane - NA.
    C. Other comments
        Army Corps permit issued after the fact.

Site Tri-County Milled Fill, South Carolina--

I. Site characteristics
    A. Location
        North of Newmarket Creek, West of Cooper River,
        lat. 32°48'N, long. 79°56'W.
    B. Hydrology
        Former marshland.
    C. Geology
        Dredged spoil underlaid by organic soils.

II. Landfill operation and effects
    A. Operation
        1. Area - 100±acres.
        2. Time in operation - NA.
        3. Amount/type of material - undetermined volume of shredded/milled MSW.
    B. Effects
        1. Leachate - NA.
        2. Water quality monitoring - NA.
        3. Bioassays - NA.
        4. Available heavy metals - NA.
        5. Total heavy metals - NA.
        6. Methane - NA.